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FOREST PRODUCTS RESEARCH 1948

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

WITH THE REPORT OF
THE DIRECTOR OF FOREST PRODUCTS RESEARCH

FOR THE YEAR
1948

LONDON: HIS MAJESTY'S STATIONERY OFFICE
1950

FOREST PRODUCTS RESEARCH BOARD

31st December, 1948

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1948

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to submit our report for the year ending 31st December, 1948.

The year has brought no major changes either in the research policy or in the work of the Laboratory. The volume of advisory and short-term work for industry is still steadily increasing, and the testing and assessment of new species, mainly from colonial sources, continues to be a major preoccupation. The need for full dissemination of the information being gained on these timbers and for the study of their possible uses in industry has, indeed, made it advisable to reinforce the staff on the utilization side.

Notwithstanding the continuing increase in advisory work, the burden of which is especially heavy, recruitment of scientific staff during the year has permitted a limited resumption of long-term projects, particularly on the biological side. The amount of this work is still far below what we regard as necessary for the well-being of the Laboratory in general, and in particular for the development of the basic knowledge on which the advisory work rests, as well as the training in research of its younger officers, but we are gratified to see that improvement has taken place.

We note with satisfaction the approval granted for the provision of four new buildings at the Laboratory. In our last report we recommended an expanded programme on the theory and practice of woodworking. The new woodworking laboratory will not only provide working space for carrying out this programme, but will also end the present unsatisfactory position of having only one set of machines for both research and the general production work for the Laboratory. In view of the expansion of the work on full-scale testing of structures, we are also glad to note the provision of a new timber structures laboratory to replace the present adapted building with its cramped conditions and inadequate headroom. The new addition to the premises of the Seasoning Section, part of which is at present inconveniently accommodated in a temporary hut, will permit of seasoning and wood bending research being again carried on under one roof. The fourth project provides for a much needed extension of the present general woodworking machine shop.

During the year, six senior officers have made special visits abroad. The diversity of the Laboratory's interests is reflected in the objects of these tours. Those to the Scandinavian countries were concerned with insect pests, the physical properties of wood, and problems of growth and quality; and those to America, with timber mechanics and wood chemistry. We feel that these opportunities of meeting colleagues in the colonies and in other countries and of gaining first-hand knowledge of recent advances in research and technique are

of inestimable value not only to the Laboratory itself, but also to the industry it serves; for personal contacts with scientists and technicians abroad and the opportunity of first-hand study of the position of science and practice elsewhere in the world enables the officers concerned to advise industry on current problems and trends with a confidence that could hardly be obtained in any other way. We are gratified to report that two of the tours by specialist officers were made by invitation.

We have approved the formation of a third informal committee with the plywood industry—the Plywood Research Panel. With the coming into full operation of the plywood laboratory, it is of great importance that the programme of technical research should be planned to yield data of immediate and advantageous application by all manufacturers, however diverse their methods of production. This is clearly a matter for discussion with the industrial technicians, and the new Panel has been formed to advise upon the work, and to keep the programme under continuous survey.

As regards the work accomplished by the Laboratory during the year we are well satisfied, and we are pleased to record the steadily increasing use made by industry of its resources. A description of the various projects on hand or completed will be found in the Director's report. Among these we note the following items of particular current interest:—

CHEMICAL WORK ON TROPICAL TIMBERS

The investigations for the Colonial Products Research Council are going on satisfactorily. Analysis of certain tropical timbers has revealed some very interesting substances, which are now being investigated. The conversion of existing huts for the pilot plant for making hardboard from tropical timbers is now well in hand, and the machinery is being installed as delivery takes place.

ENTOMOLOGICAL WORK

The experimental work on the spraying of timber stacks with a D.D.T. emulsion for protection against *Lyctus* attack has been successfully carried to the commercial scale. Recommendations and instructions have been issued both directly to the trade and also through the press.

The outbreak in Surrey of infestation by the house longhorn beetle (*Hylotrupes bajulus*) marks the first serious depredation by the insect in this country. The Laboratory is co-operating with the local authorities and with the Ministry of Health, and a senior officer has visited the Scandinavian countries, where the insect is an established pest, to get information on the most up-to-date methods of combating it.

RADIO FREQUENCY DRYING

The general investigation of the possibility of seasoning timber by radio frequency has been concluded. Both practical and economic considerations make it unlikely that the method is possible for the seasoning of timber in bulk. It may, however, be applied successfully to certain types of dimension stock, and to some kinds of bends, and these fields of limited application are now being explored.

WOOD BENDING

Among the year's publications is the handbook " Solid and Laminated Wood Bending ". We believe this to be the only extant book on the subject, and welcome its addition to the series of treatises in those fields of timber technology in which the Laboratory is pre-eminent. We are pleased to record that the French authorities have requested permission to have the work translated.

E. J. SALISBURY,
Chairman

January, 1950

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1948

INTRODUCTION

During the year 1948 highest priority has been given to those projects on the Laboratory's programme which bear upon the amelioration of the national timber situation, namely to the accumulation of test and utilization data of new timbers, the search for substitute timbers and more efficient utilization. These investigations, mostly on timbers from colonial sources, together with the very large volume of advisory and short-term work now absorb most of the available time. Progress on long-term investigations in those sections of the Laboratory where they are still going on is thus of necessity very limited. Much, indeed the bulk, of the work done during the year has thus not been of a type susceptible of detailed treatment in this report, and the pages which follow emphasize rather those points worthy of special mention than the general volume of the work accomplished during the period. The amount of advisory work has again exceeded that of the preceding year by 10 to 15 per cent, and most of the time accruing from the recruitment of new staff has been taken up in dealing with it and with the tests on the new colonial timbers. In its relation to the world wide effort to improve the getting and the utilization of timber, however, the Laboratory can claim to have played its full part. Timber technology is, in its practical aspects, the handmaiden of both the producing and the using industries, and situated as it is between these, the Laboratory is especially well placed to serve both in matters of liaison and of technical advice. This is particularly reflected in the steadily increasing number of enquiries and of technical visitors, and since it will be long before saturation point is reached, it is gratifying to record the expanding use which industry is making of the Laboratory's resources. The connexions with other government establishments are also being continually strengthened, particularly those with the Board of Trade—Timber Control and Raw Materials Department—the Colonial Office and the Ministry of Works, and with the Defence Services, with whom co-operative work is in hand. The services of the Laboratory's specialist officers have been much sought as advisers upon technical committees such, for example, as the Keith Price Committee, the Timber Economy Panel of the Ministry of Works, and the numerous timber committees of bodies such as the British Standards Institution.

In view of the continuing economic stringency, the programme of work lays emphasis upon those investigations likely to yield results of practical value during the next four-year period of reconstruction, and in the broader view of national interest they are not wholly confined to timbers for the United Kingdom or Europe; they include for instance work upon certain timbers more likely to be of local use, since improved utilization of these will materially assist in the general economics of timber production and export to the United Kingdom from that particular region. The increasing importance to this country of colonial timbers for home consumption has thus resulted in an augmented allocation of services to their development, and the recognition of the Laboratory's wider

interest and commitment in this field was implicit in the two recent visits to tropical Africa on utilization and sawmilling by senior members of the staff.

The assessment of timbers, mainly from West Africa and British Guiana, likely to be of use in industry, either as solid wood or as plywood, proceeds steadily, as also the chemical investigations into certain of these timbers for the Colonial Products Research Council. Mention may also be made of the entomological work being carried on, in co-operation with the forestry services in West Africa, Malaya and British Honduras, upon the control of damage by pinhole borers and other pests, and of the investigations into the durability of plywoods under tropical conditions being carried out in West Africa, jointly with the Ministry of Supply. All such overseas investigations into improved utilization have a direct bearing on the supplies of suitable timbers to this country.

The more extensive utilization of these timbers in this country requires, in addition to the trade machinery for their provision and transport, that technological industrial studies should be made. During the past few years it has been possible to make sporadic and limited studies of this kind by fitting them into the touring programme of officers visiting in different localities. Arrangements are now in hand to recruit staff for the systematic prosecution of this work, which yields valuable information on such matters as trends of consumption, the particular qualities essential for specific uses, and the possibility of finding substitutes for traditional timbers now in short supply or unavailable.

In its relation to the world timber situation the Laboratory is playing an increasing and appropriate part. Within the framework of the Empire Forestry Conference, the Standing Committee on Forest Products Research has set up sub-committees on terminology, timber mechanics, composite wood and preservation, the last two with the United Kingdom member as convenor. Through these sub-committees yet closer contact and co-operation between the corresponding groups of specialists are maintained throughout the Commonwealth.

In the field of European economic recovery, those countries participating in the Marshall plan for aid to Western Europe are pledged to develop their timber resources to the best advantage. In matters of development, substitution, and timber economy in housing, this country has made very substantial progress, and the Laboratory, through its representatives on the British delegation to the meetings of the Organization for European Economic Co-operation, has been able to render valuable assistance in the formulation of measures to be taken to improve the general timber situation in Europe. It is also represented on the Chemistry and Timber Mechanics sub-committees of the Food and Agriculture Organization of the United Nations.

GENERAL

BUILDINGS AND EQUIPMENT

Plans have been completed for the conversion into permanent chemical laboratories of two huts erected for the late Ministry of Home Security and recently vacated. One of these will house the pilot plant for the experimental manufacture of hardboards from tropical timbers, which is being carried out for the Colonial Products Research Council. The conversion of these huts, which will shortly begin, will not only provide the facilities for this work, but will also go some way towards relieving the congested conditions of other sections elsewhere in the Laboratory.

During the year, also, a draft scheme was submitted for the erection of a new woodworking research building and a new timber structures laboratory and for additions to the existing woodworking machine shop and the seasoning laboratory. At present woodworking research and the production work for other sections of the Laboratory are carried out on the same set of machines. The new building will enable research and production to go on independently, with a great saving of inconvenience and delay. Investigations upon timber structures are now carried on in a building which is an adapted timber store, a one-storey building whose roof trusses interfere with the erection of the structures for test. The new laboratory will provide headroom for a full-sized dwelling-house roof, and length for the testing of single members up to 75 ft. long. Here also the liberation of space will allow for the much-needed expansion of other sections. The addition of a wing to the seasoning building will enable the subsection of Wood Bending, at present partly accommodated in a temporary hut, to end the inconvenience which this fragmentation involves.

The detailed plans for all the buildings are almost complete.

TOURS

Three tours have been made during the year to the Scandinavian countries. In the spring the head of the Section of Physics paid a visit to Sweden at the request of the Svenska Träforskningsinstitutet to give a course of lectures on the hygroscopic, elastic and plastic properties of wood, its structural fibres and its constituent gel material. The preparation of these lectures afforded the opportunity for assembling from the various scientific papers the work done during the last ten years at the Laboratory, and one result of this very successful visit, for which thanks are due to the Swedish authorities, will be the publication in 1949 of the lectures both in Sweden and by H.M. Stationery Office in this country.

The Laboratory was represented at the Eighth International Congress of Entomology at Stockholm in August 1948. The opportunity was taken by the delegate to visit laboratories and colleagues in Sweden and Denmark with regard to investigations upon wood-boring insects and particularly to the details of measures for the control of the house longhorn beetle (*Hylotrupes*) at present of immediate interest in this country because of the increase in its destructive activity referred to later in this report (page 39). During the tour entomological information was also collected for the research branch of H. M. Forestry Commission.

In the autumn, a visit was made to Germany, Norway and Sweden in connexion with the problems of the effect of the rate of growth upon quality in timber and of the incidence of disease following the pruning of softwoods. Both of these problems lie in that part of the Laboratory's programme which borders upon the work of the Forestry Commission. Not only were fruitful discussions held on these questions, but very useful information was obtained about the present state of timber and forestry research in the Scandinavian countries.

Two visits to America were made during the year. The head of the Section of Chemistry attended the meeting of the Wood Chemistry Sub-committee of the Food and Agriculture Organization at Appleton, Wisconsin, and the head of the Section of Timber Mechanics a meeting of the Timber Mechanics Sub-committee of the Standing Committee on Empire Forest Products Research. Both officers took the opportunity to visit the Forest Products Laboratory at

Madison and also a number of industrial firms, in particular those engaged upon orders for special apparatus for their sections' work.

PLYWOOD RESEARCH PANEL

The completion of installation of the plant in the plywood laboratory now makes it possible to carry out full-scale trials of timbers potentially useful for the production of veneers and plywood, and an important part of these trials is the assessment of yield. To be of use to industry the data obtained by any system of assessment must be expressed in a form which can easily be translated in terms of the method of estimation of yield employed by any industrial firm. This is a difficult task clearly to be undertaken only with the aid of industry itself, and to this end the Plywood Research Panel has been convened. It is a small panel of technical representatives of the plywood manufactures and the Laboratory staff, of the same informal character as the two existing panels for plywood, the Adhesive Makers' Panel and the Radio Frequency Panel.

PUBLICATIONS AND RECORDS

Five new publications were issued through H. M. Stationery Office during the year. They include Special Report No. 7 " Elasticity of Wood and Plywood ", Bulletin No. 21 " Flooring Hardwoods ", Leaflets No. 42 " Kiln Drying Schedules " and No. 43 " D.D.T. Spray Treatment for the Prevention of *Lyctus* Attack ", and the book " Solid and Laminated Wood Bending ", which so far as is known is the first work in the English language on this subject. H.M. Stationery Office has already been approached on the question of the publication of a French edition. Requests to publish foreign editions of two of the Laboratory's other publications were received, namely, from the United States of the book " Decay of Timber and its Prevention " and from Brazil of the " Handbook of Woodcutting ".

Forest Products Research Leaflet No. 42 " Kiln Drying Schedules " replaces, with up-to-date information, the former Forest Products Research Record No. 26, of the same title, which went out of print during the war. Details of the other Stationery Office publications and of the papers issued through the Scientific and Technical Press during the year are given in Appendix II. In addition, twenty reports were prepared for limited distribution, dealing mostly with timber-drying and plywood.

INSTRUCTION

No systematic courses of general instruction have been held during the year, but it has been possible to arrange a few special courses, notably one on timber technology for the instructors of the Timber Development Association. The customary parties of undergraduate forestry students came from the universities of Cambridge, Aberdeen and Bangor, and the usual advanced course was provided for the Oxford post-graduate students, who include in their number a high proportion of colonial forest officers.

The courses of training for kiln operators continue to be one of the Laboratory's important contributions to industry. During the year 8 courses were held, with an aggregate attendance of 70 trainees.

DISSEMINATION OF RESULTS

Visits

A large number of routine and special visits has been made by members of staffs to many parts of the country either for advisory purposes or for the

inspection of structures attacked by beetle or dry rot. At the request of the Ministry of Commerce a senior officer visited Northern Ireland to lecture upon the work of the Laboratory and to carry out a large programme of visits which had been requested by individual firms.

Lectures

While every effort has been made to accede to requests for lectures by technical bodies it has again been necessary to curtail the acceptance of definite dates which would involve an absence of days from the Laboratory. Where possible, lectures have been arranged at short notice when an officer is in the district on other duty.

Exhibitions and Films

The film on Dry Rot in Timber has been re-edited and new material incorporated, together with a spoken commentary. The film should be ready for distribution in 1949. The taking of shots for the films on Wood Bending and on Defects in Trees is continuing.

ADVISORY AND SHORT-TERM WORK

While a consistent increase in all sections of the Laboratory has been maintained some show a striking increase in the volume of advisory work. Enquiries in mycology were up by 30 per cent on the figure for 1947, and those in plywood, woodworking and seasoning problems by 25 per cent. The advisory work on wood-destroying insects and their control exemplifies the general position now reached by the Laboratory as a whole: the 954 replies to enquires (excluding 'leaflet' replies) in entomology represent an increase of 39 per cent over the pre-war peak figure in 1938 and these have, moreover, been dealt with by a reduced staff. The number of replies to enquiries in general utilization and properties of timber also constitutes a new record, in addition to a substantial increase in replies given by telephone. For the whole Laboratory the approximate totals are:—

Technical enquiries dealt with by all means (mail, visit, telephone, but excluding routine reply by leaflet) ..	11,000
Technical enquiries dealt with by letter or report ..	4,000
Leaflets despatched	42,500

While much of the advisory work presents no outstanding features, some of it yields ideas for future research, and some is of interest because of the unusual nature of the enquiry or because the problem demands special ingenuity or technique.

PROGRAMME OF RESEARCH

COLLECTION OF TIMBER SPECIMENS; IDENTIFICATION STUDIES

Increases in both scientific and technical staff have enabled progress to be made in classification and descriptive work which had fallen into arrears. In addition to some five hundred miscellaneous timber specimens added to the reference collection during the year, work has been resumed on the systematic

examination and classification of several large collections which have been waiting to be incorporated. A notable acquisition is a collection of some six hundred Brazilian timbers, correlated with herbarium material, received from the Smithsonian Institution, Washington, U.S.A., under exchange arrangements. Another large collection of miscellaneous timbers from the Cambridge School of Forestry has been classified and converted into hand specimens or exhibition panels. The bulk of this material has been passed on to the Timber Development Association for the use of their classes in timber technology.

Considerable progress has been made with the card key for the identification of hardwoods (based on features visible with a hand lens) which is being extended and revised for publication. The more important " new " timbers which have been imported in recent years have been incorporated in this key. The key based on microscopic features, which is the basis of routine work on the identification of hardwoods, is also being brought up to date. A paper on the identification of softwoods, originally published in the Journal of the Linnean Society, has been revised and prepared for publication as a Forest Products Research Bulletin.

GENERAL TESTS OF TIMBERS

The testing of timbers from overseas, and especially from the colonies, continues to be allocated the highest priority. At the end of 1948 there were twenty-three hardwoods under test, ten awaiting test, and eight selected for testing. Their origin was as follows:

West Africa	25 species
East Africa	8 species
British Guiana	4 species
Malaya	2 species
Chile	2 species

The genera concerned were:
Acacia, *Afrormosia*, *Afzelia*, *Albizzia*, *Aningueria*, *Antiaris*, *Aucoumea*, *Berlinia* (2 species), *Brachylaena*, *Brachystegia* (4 species), *Celtis*, *Cistanthera*, *Cynometra*, *Daniellia*, *Diospyros* (2 species), *Distemonanthus*, *Entandrophragma*, *Gossweilerodendron*, *Isoberlinia*, *Laurelia*, *Mitragyna*, *Mora* (2 species), *Nothofagus*, *Ocotea*, *Parashorea*, *Parinari*, *Piptadenia*, *Sclerocarya*, *Scottelia*, *Shorea*, *Sterculia* (2 species), *Tabebuia*, *Terminalia*, *Turraeanthus*.*

After verification of identity, these timbers undergo a full range of tests, including those on seasoning and stability, strength, durability, permeability to preservatives, woodworking, steam-bending, and, in some instances, special tests such as peeling and gluing properties for assessing suitability for manufacture into plywood.

DATA FOR UTILIZATION

The Timber Control Hardwood Procurement Scheme, under which importers are permitted to purchase certain kinds of overseas timbers on their own account, has resulted in a large number of unfamiliar timbers being put on the market, and this has caused an unprecedented demand for general information on these timbers, for the identification of commercial samples, and for advice

* This list does not include timbers received in small quantities for subjection to specific tests—e.g. seasoning, woodworking or bending.

on a wide range of questions on utilization. In addition to the full-scale tests on selected species, studies have therefore been made on the less familiar species now being imported from overseas, many of which are not included in the standard reference books available to the general public. Some of these timbers are of only ephemeral interest in the present abnormal period of timber shortage and currency restrictions and it would not be reasonable to carry out comprehensive investigations on all the timbers at present in use even if it were possible to do so. In order to meet the demands of industry for " something to be going on with ", information notes have been prepared, based on the examination of hand specimens combined with such technical data as are available in the Laboratory's records. It has frequently been necessary to start by establishing the identity of a commercial consignment imported under some obscure vernacular name, and when this is so, importers have been asked to supply samples for examination. Thanks to the co-operation of the timber trade a large number of timbers has been dealt with in this way and the information obtained has been extremely useful in advising industry how to make the best use of the supplies available. A typical example of the application of these data may be seen in the recent visit of a group of motor-vehicle body makers who, together with their timber suppliers, came to the Laboratory and reviewed, with the relevant specialists, about 100 imported hardwoods of potential value for motor body construction.

GREEN PRUNING OF SOFTWOODS

Examination of the wood of "green-pruned" spruce stems (stems from which living branches had been pruned) from four Forestry Commission areas was completed. These were Tintern (Monmouthshire), Bodmin (Cornwall), Gwydyr (North Wales), and Thornthwaite (Cumberland). In all but the first area both Norway and Sitka spruce were sampled. In no instance in the knots examined had disease followed the pruning. Yet some of the stems from Bodmin, Gwydyr and Thornthwaite showed slight but definite signs of canker in the form of eruptions in or below the bark, black resinous bleeding and symptoms resembling the very definite canker in pruned Norway spruce from Perthshire. The usual time to heal over completely was five years, i.e. that was the time until the annual rings ceased to bend in towards the knot and began to run straight over and past the pruned snag.

A report has been received from forest research authorities in Sweden to the effect that they find that Scots pine can be green-pruned safely but Norway spruce can be green-pruned only in the south, where resin flow and healing are quick enough to prevent disease. In the centre and north of Sweden, green-pruning of spruce may produce canker. This agrees with the rather sparse but definite cases of canker found in spruce after green-pruning in Great Britain. Work on rate of healing and freedom from disease after green-pruning is proceeding in collaboration with the Forestry Commission and the Imperial Forestry Institute, Oxford, chiefly on Norway and Sitka spruce.

WOOD-WATER RELATIONSHIPS

The partial drying of wet hygroscopic materials by the method of centrifuging is well known, but the theoretical calculation of the equilibrium moisture content remaining, after prolonged centrifuging under known conditions, has not been satisfactorily solved. An exact treatment is possible, however, by using

the theory of swelling stresses, if the stress set up in the material, owing to its being pressed up against the end of the tube, is calculated. In the ordinary centrifuge, the stress is compressive so that the vapour pressure is raised and the material dries. If however the material is strong enough to be attached at the root end, as in an air-screw blade, the vapour pressure will be lowered and the moisture content will increase. Exact expressions for the change in moisture content of hygroscopic and porous materials under given conditions of centrifuging have been derived.

On the experimental side, work has continued upon the determination of the sorption isothermals of wood. Refinements in technique have shown that the curves obtained simultaneously on several samples of the same species under identical conditions are not necessarily identical. The samples of lower density show the greater sorption.

Further experiments have also been made on the change of sorption of wood blocks when swelling under directional restraints.

ELASTIC AND PLASTIC PROPERTIES OF WOOD

A further study has been made of the effects of sustained loading on the Young's modulus of wood in bending[1]. Strips of beech and Douglas fir were conditioned to 45 per cent, 60 per cent, 75 per cent and 90 per cent relative humidity. The strips were clamped at one end to form cantilevers, and loads were attached at the free end such that the maximum fibre stress was about half the ultimate strength in compression. The load was kept on for 7 days, readings of the frequency of vibration of the strip being taken daily. The load was then removed, and observations of the frequency again taken daily for a further 7 days. The whole procedure was repeated twice thus completing three cycles of loading and unloading. The Young's modulus is proportional to $1/T^2$, where T is the period of vibration, and the results show that almost always the value of $1/T^2$ rises when the load is applied and drops when the load is removed. A control experiment with a steel strip showed no effect whatever. On the wood strips, the effect is relatively small at all humidities, but is smallest at the lowest humidities, and rises with the humidity. The increase in modulus on loading at 45 per cent relative humidity, averaged over all the observations, is about $\frac{1}{2}$ per cent, whereas at 90 per cent relative humidity, the average increase is about 3 per cent. These changes are too small to be of much practical significance, but may have to be taken into account in interpreting the results of creep experiments on wood, at least at the higher humidities.

The first experiments on the creep of plywood have been completed, and the experiments on solid wood are still in progress. A preliminary analysis of the experiments on plywood indicates that the creep is relatively insensitive to moisture content at 60 per cent relative humidity and below, but that above this humidity, the creep increases rapidly with increasing moisture content.

It is usual in theoretical work on elasticity to assume that the stresses in a material are linear functions of the strains, and for this purpose, the elastic behaviour of wood ideally needs 9 independent constants for its specification. It is possible, however, that this simple assumption is not always adequate, and some attention has been given to the consequences of assuming that the stresses are expressed not only by terms involving the first power of the strains but also

[1] HEARMON, R. F. S. The Effect of Sustained Bending Loads on the Young's Modulus of Wood. (International Congress on Rheology, Holland, September 1948.)

by terms involving squares and products of the strains. It appears that 20 additional constants are then required for wood, and the complete scheme of these constants has been worked out.

The survey of work on elastic and allied properties of wood and plywood, which has been in preparation for some time, was published in September as Forest Products Special Report No. 7, under the title " Elasticity of Wood and Plywood ".

DIELECTRIC PROPERTIES OF WOOD

The development of high frequency heating has emphasized the need for a thorough investigation of the electrical properties involved, namely, dielectric constant, power factor, and conductivity.

An apparatus for measuring these properties has been built, and considerable time spent in calibrating it, and in obtaining or making suitable components. Essentially, the apparatus consists of a tuned circuit comprising condensers and an inductance, with a valve voltmeter to observe the conditions of tuning. One of the condensers consists of two parallel plates, the distance between which can be varied by means of a micrometer screw; a disc of wood can also be inserted between the plates. The distance between the plates, and the sharpness of the resonance curve are observed, both with and without the wood in position, and the required properties of the wood deduced from these observations. The apparatus works satisfactorily for wood at moisture contents below about 20 per cent, but difficulties have been encountered with very wet wood owing to the high dielectric constant and power factor. By using very small cylinders of wood as the test specimens, so that only a fraction of the space between the electrodes is filled, it has, however, proved possible to measure the dielectric properties of saturated oak and wych elm specimens at frequencies between 20 kc/s and 60 mc/s. The results show that both the power factor and dielectric constant increase with decreasing frequency, and, at frequencies below about 1 mc/s, the dielectric constant becomes greater than that of water itself. The conductivity, which is proportional to the product of frequency, the dielectric constant and the power factor, is much less sensitive to frequency than is the conductivity of dry wood, and consequently, in applying dielectric heating to wet wood, it is not so important to work at high frequencies.

TEMPERATURE AND HUMIDITY CONTROL

Work has continued on the construction of a cabinet for use over a wide range of controlled temperature and humidity. The photoelectric dew-point method of humidity control, although sensitive, proved unreliable over long periods of time, and work on this was suspended for the time being in favour of wet and dry bulb contact thermometers. These are reliable in operation but do not seem sensitive enough for our purpose as they show variations of up to 5 per cent in the relative humidity. Thermocouples are at present being tried in place of the wet bulb thermometer.

KILNS AND KILN-SEASONING. ORTHODOX METHODS

Tests in Large Kilns

The large kilns have been employed mainly for the drying of commercial loads of timbers that were reputed by the firms to whom they belonged to be difficult to season in the kiln. They have been used for the seasoning of such material as 2-inch rauli (*Nothofagus procera*), ½-inch elm (*Ulmus procera*), 3-inch

western red cedar (*Thuja plicata*), and oak (*Quercus robur*) squares and planks up to 4½ inches in thickness.

Of these, the oak squares, though refractory, responded favourably to the standard schedule of treatment, and the elm seasoned with remarkably little distortion, mainly as a result of very careful piling and the use of low temperatures. The thick planks of western red cedar, however, proved surprisingly difficult to season to a uniform moisture content, since a limited number of pieces were unusually retentive of their moisture and tended to honeycomb and collapse when attempts were made to reduce drying times to within reasonable limits. Despite the fact that much of the material dried fairly rapidly and well, it has therefore been necessary to class the species as a refractory softwood.

Tests in Small Kilns

Comparatively small-scale tests have been carried out in the intermediate and small model kilns to determine the seasoning properties of a number of exotic timbers. In all, twenty-three runs have been carried out on nine different species. A leaflet dealing with the seasoning properties of a number of these is in course of preparation.

Alterations and Additions to Plant

The erection of two new intermediate kilns and one model has been completed and these units have been in almost continuous use.

Two of the original model kiln units have deteriorated to such an extent that they have had to be dismantled. Two new units of improved design are intended to replace these in the near future.

The old basement fan kiln has been converted into a side-fan type unit, and several new features such as an aluminium drop type door and novel venting arrangements have been incorporated.

KILN-SEASONING. UNORTHODOX METHODS

Chemical Seasoning

Tests have been carried out in co-operation with the Timber Development Association at the Swindon Works of the Railway Executive to determine whether degrade in the kiln-seasoning of thick oak may be reduced by treatment with urea. The 3-inch planks of green oak to be used for wagon building were dipped or soaked for periods varying from five seconds to forty-eight hours in a saturated solution of urea and then built into a pile with a number of untreated planks to be kiln-dried. The kiln used for these tests was by no means efficient and, though the time taken to season the wood was considerable, both treated and untreated planks were badly split at the end of the drying period. There was no indication whatsoever that the comparatively short periods of soaking in urea had in any way lessened the tendency for the wood to degrade during kilning.

Radio Frequency Drying

Investigations commenced in 1947 into this novel method of seasoning were continued during the year under review.

The equipment obtained and built for the carrying out of the tests consists essentially of a 5 kw output radio frequency generator connected to a small and independently operated drying-kiln, which is illustrated in Plate 1(A).

The possibilities of two distinct methods of drying by such means were investigated, the first by heating the wood to the boiling point and extracting the moisture as steam, and the second by inducing a temperature gradient from centre to surface so as to cause moisture to transfuse outwards as a result of the vapour-pressure differences established at temperatures lower than the boiling point. The surface temperatures of the wood were reduced below those of the interior by passing cool, but humid air over the timber.

Tests by the first method (the so-called " boiling method ") have in general indicated that those timbers that offer little resistance to impregnation with liquids under pressure are reasonably tolerant of such treatment, but that impervious species, such as oak, tend as a result of the steam pressures induced to burst in a manner illustrated in Plate 1(B).

Tests on the " temperature gradient " method showed that most woods could be dried satisfactorily by this process, but that to avoid severe surface stressing and splitting, temperature differences had necessarily to be kept relatively small, and drying times comparatively long. For example, ten days' continuous treatment were required to reduce 1-inch English oak from the green to a final average of 12 per cent moisture content.

It would appear that the successful application of radio frequency heating to the seasoning of timber will be limited by practical and economical considerations to the drying of dimension stock of permeable species of sufficient value to make speed of drying, rather than cost, the overriding factor.

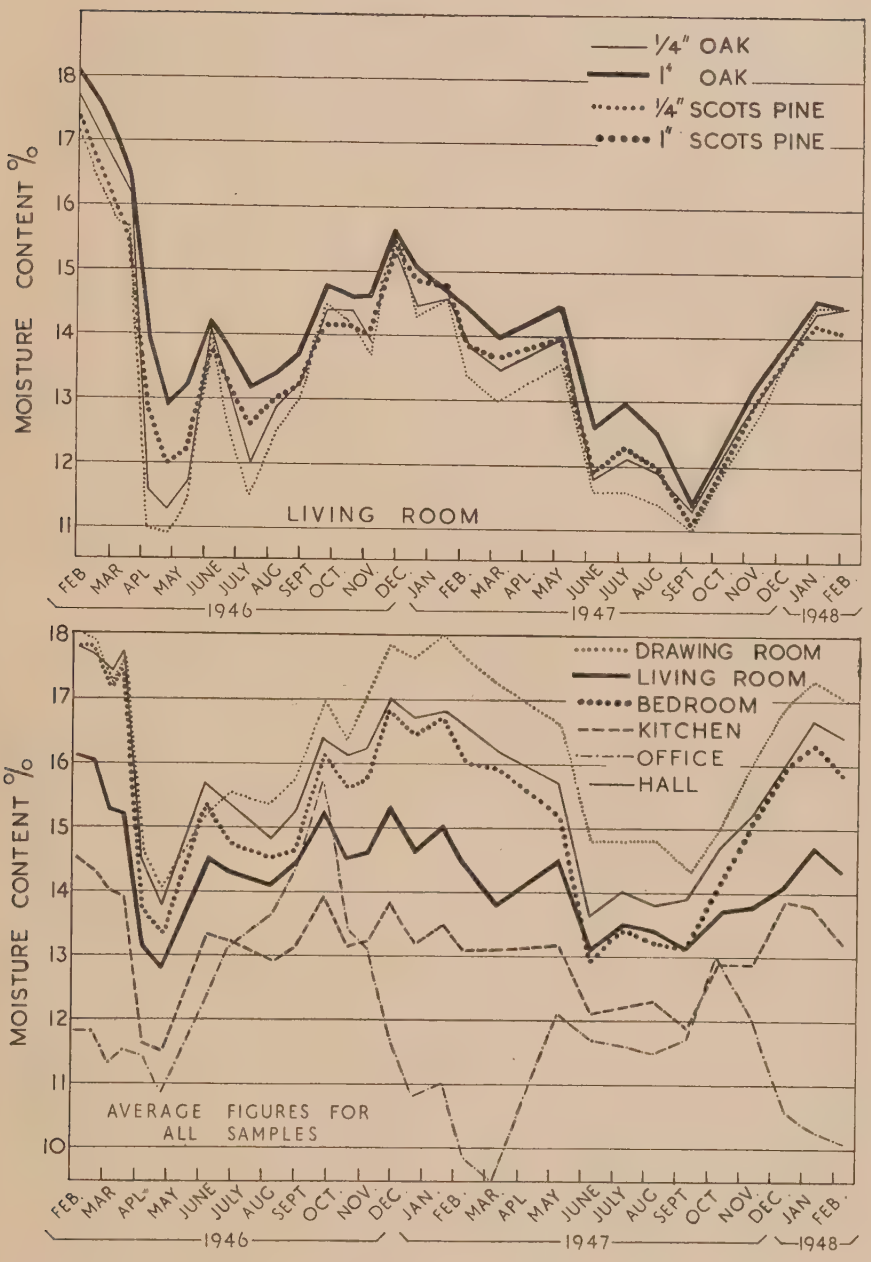
SEASONAL VARIATION IN THE MOISTURE CONTENT OF WOODS KEPT IN DIFFERENT ENVIRONMENTS

As timber plays such an important part in the construction and furniture of the ordinary dwelling house, knowledge of its moisture relations in domestic interiors is necessary, and before the war data had been obtained about seasonal variation of the moisture content of wood in different parts of the house. Under post-war conditions of reduced fuel supply a further series of tests was undertaken to discover whether diminished heating had had any appreciable effect upon the range and average in such environments.

Samples of 1-inch and $\frac{1}{4}$-inch oak and Scots pine were placed in the living-rooms, drawing-rooms, bedrooms, kitchens and halls of four houses at Princes Risborough, which were heated by open fires or domestic hot water boilers. In addition a set of samples was placed in a centrally heated office at the Laboratory.

From the curves (Fig. 1) illustrating some of the seasonal moisture-content values recorded, it may be observed that an appreciable increase in moisture content occurred in living-rooms and bedrooms during the winter months above those of the summer. In a centrally heated office, on the other hand, maximum moisture content values were obtained during the summer and autumn when the heating was off.

The average moisture contents of the samples in the living-rooms and bedrooms were found to be 14 and 15 per cent respectively, the oak on the average being about half a per cent higher than the Scots pine. Even taking into consideration that an abnormally wet summer and severe winter were experienced during the period of these tests, it would appear on comparing these sets of readings with similar ones taken before the war, that somewhat higher moisture conditions prevail than heretofore. A probable reason for this apparent overall increase in the moisture content of timber in dwelling houses is the present restricted use of fuel.



SEASONAL VARIATION IN MOISTURE CONTENT OF OAK AND SCOTS PINE SAMPLES KEPT IN VARIOUS ENVIRONMENTS IN PRINCES RISBOROUGH FEBRUARY 1946 TO FEBRUARY 1948

Fig. 1

MISCELLANEOUS WORK ON SEASONING

On behalf of the Ministry of Works a considerable amount of time is still being spent in connexion with the kiln-seasoning of English oak for the rebuilding of the House of Commons. Much of this oak, some of which is being seasoned at the Laboratory, is of exceptional thickness, and prolonged, careful drying treatments have been involved. In addition to the supervisory visits made to the industrial kilning plants where the oak is being dried, others have been made to the joinery and wood-carving firms in order to investigate and advise upon the conditions of storage and manufacture and to obtain information on the behaviour of the timber while it is being worked. Small consignments of Australian blackbean for the Speaker's Chair, and of New Zealand puriri for the Dispatch Boxes have been converted and are in process of kiln-drying at the Laboratory.

Other interesting short-term investigations in the seasoning of timber included tests on the effect of severe moisture changes upon the behaviour of wooden safety blocks for electric railways, the behaviour of specially constructed doors subjected to changes in humidity, and on the reconditioning of thick planks of severely collapsed Tasmanian oak. On behalf of the Timber Control, the plans of numerous commercial installations have been examined and reported upon in detail. Assistance was also given on the compilation of the new Kiln Drying Charges Order.

WOOD BENDING

The bending properties of numerous exotic timbers have been investigated, including such species as idigbo (*Terminalia ivorensis*), albizzia (*Albizzia ferruginea*) and ogea (*Daniellia ogea*). None of the tropically grown species tested in solid form has been found to possess good bending properties in any way comparable with, say, beech or ash. The limiting radii of curvature of thin laminae obtained from these imported woods were also determined to assess their value for laminated bending (Plate 2). While most of them were found to be satisfactory, none of them is as good as beech.

Tests have been carried out to determine whether the bending properties of ash are improved by storing in log form for a period before conversion, a claim sometimes put forward by manufacturers of hockey sticks. Test results failed to justify this contention.

The possibilities of setting solid bends by radio frequency heating have been investigated. Solid bends made from 1¼-inch square beech, ash and elm could be set in less than 10 minutes by such means, as against the normal period of as many hours. Some difficulties, however, were experienced in drying uniformly and simultaneously a number of bends in the one strap. Oak proved refractory, and setting periods for this wood were of the order of one to two hours.

Determinations of the limiting radii of curvature of various forms of plywood have continued, and a report of the findings issued.

STRESS-STRAIN RELATIONSHIPS OF STEAMED WOOD

In connexion with investigations into the bending properties of wood, tests have been made to determine the influence of various factors on the compression stress/strain relationship of steamed wood. Limitations imposed by the equipment available necessitated using prismoidal test pieces in order to enable compression to be measured over the whole length. It was found that the deformation took a different form from that which occurs when wood is bent,

and this appears to be due to the difference between the conditions of support of the wood in the test piece and those at the instant of bending during the bending operation. It is probable that results more nearly in accord with what happens during bending would be obtained by using a bobbin-shaped test piece in which compression would be measured over a central length of reduced cross-section. This possibility will be investigated when the automatic load/deflection recording equipment now on order is received.

STANDARD STRENGTH TESTS

The special interest now being taken in tropical hardwoods and the import of species new to this country have resulted in an increase of standard testing for the provision of basic strength data. The strength characteristics of the species tested during the year have proved to be unexceptional; in particular the much-needed substitutes for ash and hickory have yet to appear.

Facilities and assistance were afforded a Trinidad Forest Officer to make comparative tests of Burma teak and of plantation-grown teak from Trinidad. The quality of the young and rapidly grown plantation teak trees of about three feet breast-height girth is very promising.

STANDARDIZATION OF TESTS

The possibility of a world-wide standardization of tests is being actively explored at the present time and meetings of the Sub-Committee on Mechanical Wood Technology of the Food and Agriculture Organization of the United Nations at Geneva in June and of the Timber Mechanics Group of the Standing Committee on Empire Forest Products Research at Ottawa and Madison in September and October have been held to discuss the position. These meetings were attended by the Officer-in-Charge, Timber Mechanics Section. The main concern of the Laboratory at these meetings was the standardization of an alternative test procedure, based on the use of test pieces smaller than the customary 2 in. square section. This smaller size is required to facilitate the systematic sampling of small and second-growth trees and the preparation of matched groups of test pieces for comparative testing such as is required for investigation of effect of treatments, etc. In the view of the Laboratory an eminently suitable scheme is available in the Monnin System as used in most continental countries, which employs test pieces of 2 cm. square cross-section. In addition to its intrinsic merits, this scheme of testing has the further attraction that data obtained under it are available in respect of French and other colonial species now entering the British market. At the Geneva meeting, however, which was attended by representatives of twelve countries, there was a body of opinion in favour of test pieces based on a cross-section 1 in. square; with the unsatisfactory outcome that a compromise resolution was passed admitting both sizes. The subsequent meeting in North America of the Empire forest products specialists, at which the United States Forest Products Laboratory was represented by invitation, was held in the knowledge of the views expressed at Geneva, and agreement was reached on the 2 cm. test pieces as the only systematic standard of this order of size.

In view of these developments some time has been spent in reviewing the Laboratory's testing equipment in the light of the requirements for testing 2 cm. test pieces and in deciding what modifications and additions will be required for maximum efficiency in working.

STRUCTURAL INVESTIGATIONS

In collaboration with the Timber Development Association, a brief series of tests has been made of " Bulldog " shear connectors to provide interim information on the strength of the sizes now available. Arrangements are being made to test two sizes now being developed to suit the timber sizes popular in light construction. Some fundamental studies of shear connectors have been started, but progress under present conditions is slow.

A short series of tests of roofs has been made on the test frame which was improvised late in 1947. These investigations have afforded valuable information on a number of points of roof design and have also provided the necessary experience for the design of more comprehensive equipment for this type of work.

The chief finding from the tests confirmed our opinion that the stiffest, strongest and most economical roof is likely to be the traditional form with the internal bracing reduced to simple strutting from partition walls. At the other end of the scale, the unsoundness of the practice of strutting from flexural members, e.g. ceiling joists, was shown by a reduction of stiffness of 75 per cent. This is of interest as the practice has considerable vogue at the present time.

The suggestion was made by the Timber Development Association that the difficulty which arises from the shortage of timber in rafter lengths might be overcome by the adoption of shorter lengths joined by a simple rebated joint, situated at the point of zero bending moment, a short distance above the purlin. This was tried out in one of the test roofs with entirely satisfactory results, the rafters being intact when the roof failed in another component at a load equal to two and a half times the dead and superimposed load.

At the request of outside bodies tests have been made of a number of roof trusses of spans up to 33 ft., and of two arches: one of plywood box-section for a proposed new school, and the other of laminated timber construction for a proposed village hall. Development work was involved in some of these tests.

A general view of a roof test in progress is shown in Plate 3. A bolted and glued timber frame supported the roof structure at the wall plates, and provided anchorage for the straining screws by which the load was applied. The main screws, eight in number were housed in two cross-frames, and the loads were transmitted through spring dynamometers, the dials of which may be seen in the photograph. The rafter-loading below the eaves was effected by separate screws at the extremity of the frame, working through calibrated coil springs. To simulate uniformly distributed loading a total of 180 equal separate loads was applied to the rafters, and, as an independent system, 80 loads to the ceiling. Loading was effected by means of steel bands passing over wood bars spanning pairs of rafters or ceiling joists, up to 20 such bands (40 individual loads) being ganged to each straining screw. Plate 4 shows part of the upper intermediate links on the rafter loading system, and the loading bars and links on the end pair of ceiling joists. Slip in the joints at the eaves between the ceiling joists and the rafters was measured by means of dial gauges, and vernier tapes mounted on tubular alloy scaffolding were used to measure the deflections of the ceiling joists and rafters.

The arrangement adopted in testing large two-dimensional structures such as trusses and arches is shown in Plate 5. Support and pulling anchorages are furnished by a pair of steel joists. Radius arms pivoted on a wooden framework fixed to the stanchions of the building provide the test member with the side support normally afforded by purlins, etc. This particular illustration is of a roof truss of 30 ft. span, designed to provide economical roofing for a block of

flats. In this test the rafters and ceiling joists were loaded independently, the latter being subjected to heavier loading near mid-span where the headroom under the roof is more favourable to the storage of dunnage.

An example of a test on a smaller two-dimensional component is shown in Plate 6, which illustrates a built-up purlin of 15 ft. span, for an agricultural building, under load in a testing machine. This type of purlin represents a considerable saving in timber over the customary solid type, and the object of the investigation was to develop joints with the necessary strength. The uniformly distributed load for which the purlin was designed was closely simulated by loading at eight equally spaced points by means of steel bands coupled to a link system comprising a series of pivoted horizontal bars fixed to the straining crosshead of the testing machine. The same arrangement of test was employed in a further investigation concerned with developing a solid purlin rebated on the underside at the ends, in which the tendency for failure to occur by splitting from the rebates was overcome by gluing light vertical battens to the sides at each end.

The construction of the timber frames and girders and of the test roofs involved in these investigations has incidentally provided a useful insight into the problems involved in the fabrication of glued structures.

Much of this work on timber structures was carried out in collaboration with the Constructional Research Group of the Timber Development Association. The combination of the knowledge and initiative of this Group in the fields of design and application of timber in structures, with the wide background of knowledge of the material and the facilities, resources and experience in the sphere of mechanical testing available in the Laboratory has been an important factor in promoting the success of this work.

The straining-screw method provided a cheap, ready, and, therefore, appropriate solution of the problem of applying loads while this work was in the development stage, but it is by no means ideal, serious disadvantages being the considerable physical effort entailed, during unloading as well as loading, which becomes particularly onerous when the test schedule involves cyclical application and removal of load, together with the fact that the operator is required to work in an extremely uncomfortable position. Consideration has therefore been given to alternative methods which will permit remote control and indication of load. Taking into account the factors of cost, simplicity, and adaptability to the wide range of test conditions involved, the most suitable equipment appears to be hydraulic tension jacks. As no systematic performance data of such equipment appeared to be available, investigations have been made into the efficiency of a commercial type of jack. It was found that the hydraulic pressure is not a reliable indication of the load on the jack, particularly when the load is maintained over a long period, and alternative devices including pressure capsules for measuring the load are now being considered. A comprehensive range of jacks, capable of being adapted for all purposes, has recently been acquired from salvaged aircraft components.

To enable tests to be made of the full range of roof and other structures likely to be encountered, an adjustable steel girder test bed is being designed.

Investigations have also been started to determine the most economical use of timber in suspended floors, and to establish the efficiency of inter-joist strutting. Preliminary results of the former investigation, based on a schedule of impact tests laid down by the Building Research Station, suggest

that it may be satisfactory to employ thinner boards than have been customary. Further tests are being made with a wider range of boards and of joist spacings.

Tests of box beams incorporating timber flanges and hardboard webs, designed as substitutes for solid timber floor joists with considerable saving in timber, have been made in connexion with a scheme of prefabricated house construction submitted to the Ministry of Works.

PERFORMANCE TESTS ON DOORS

An outcome of the continuing drive for timber economy has been a variety of proposals covering the use of alternative materials and methods of construction for the manufacture of doors, some of which have been the subject of requests to the Laboratory for approval tests. As existing specifications cover only a limited number of forms of construction and define only the quality and species of timber and the dimensions of the parts, it was clear that consideration of other types of door, possibly less strong than those used hitherto, would introduce the novel principle of control by performance standards. This was discussed with the authorities concerned and it was agreed that the existing form of specification was no longer suitable and that specifications based on performance standards represented the only practicable solution. The Laboratory was asked to recommend appropriate tests. Tentative proposals are for torsion and slamming tests on doors, with kicking tests on panels. A torsion test has been set up based on the assumption that critical loading is most likely to occur in an attempt to force a door by a pressure at mid-height against a resistance at the bottom, and has been accepted in principle. The general arrangement is shown in Plate 7. The door is hung on a triangulated timber frame and the force at mid-height is applied by a wire coupled to a motor-driven straining screw. The force is measured at the bottom of the door where contact is made with a pivoted arm restrained by a calibrated coil spring. The distortion of the door is measured by means of a vernier tape. A series of tests has been made on new and old type doors to provide the necessary data to determine minimum standards of performance, and the data are now being analysed.

PERFORMANCE TESTS ON FURNITURE

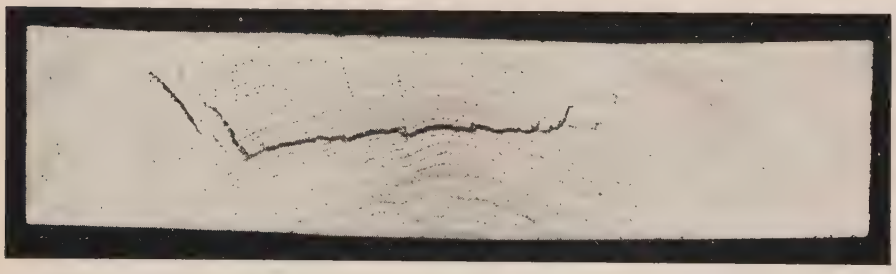
The advice of the Laboratory has recently been sought by the Furniture Directorate of the Board of Trade and by the Furniture Development Council as to the formulation of performance tests for furniture, the subject of one of the recommendations in the Furniture Working Party's report. Discussions have taken place with the Development Council, whose programme includes the provision of such tests; and to give an answer to a particular problem and at the same time demonstrate the principles to be observed in dealing with the problem, a racking test to measure the stiffness of utility tallboys was devised and demonstrated.

THE STRENGTH OF PIT PROPS

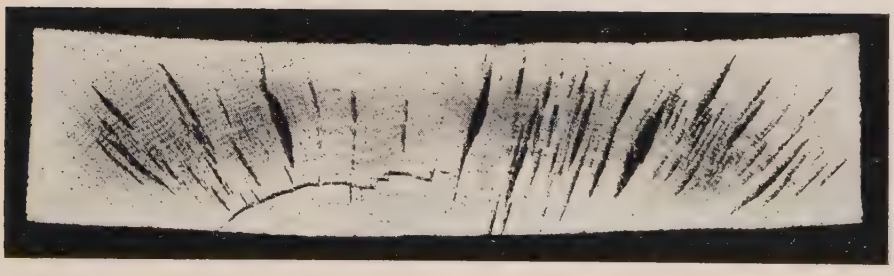
Several series of tests of pit props have been made at the request of the Timber Control in connexion with the placing of contracts abroad and the assessment of supplies furnished under contract.

At the request of the Forestry Commission arrangements are being made to test pit props of home-grown hardwoods.

(A) MODEL KILN FOR EXPERIMENTS IN SEASONING BY RADIO FREQUENCY



(*a*)



(*b*)

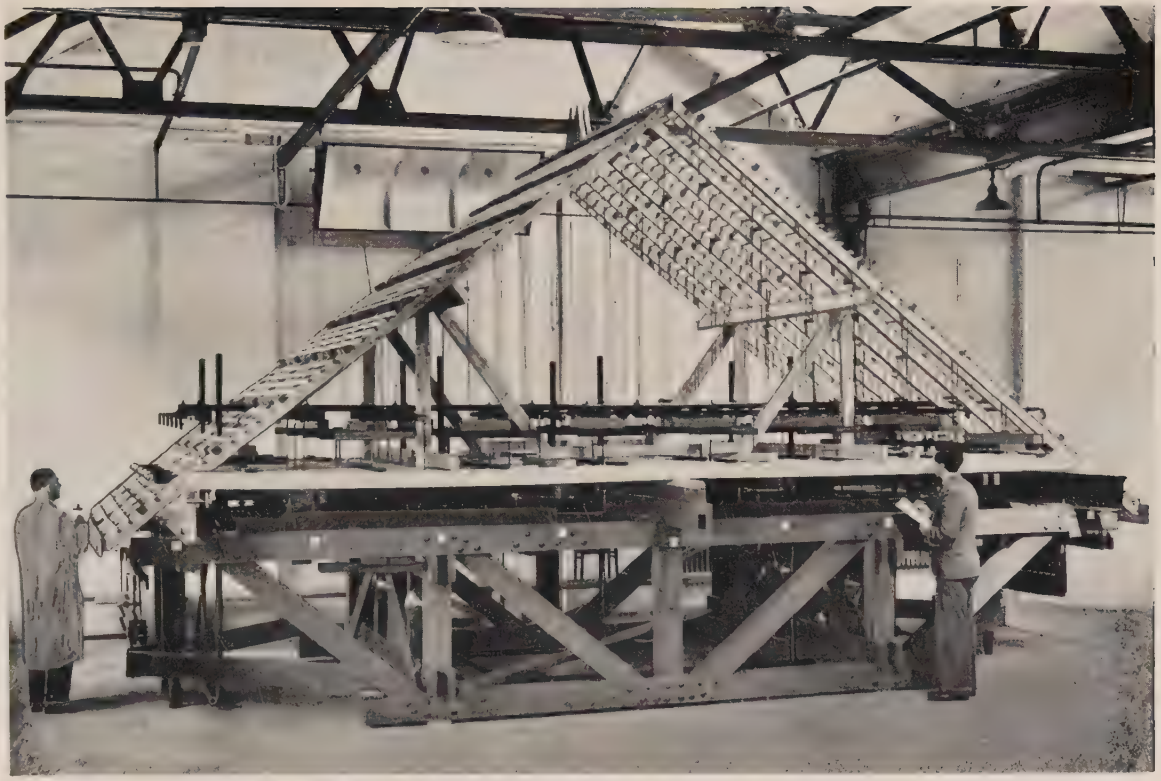
(B) SECTIONS OF ENGLISH OAK DRIED BY THE ' BOILING METHOD ', SHOWING (*a*) BURSTING AND (*b*) BURSTING FOLLOWED BY HONEYCOMBING

PLATE 1

DETERMINATION OF THE LIMITING RADIUS OF CURVATURE OF LAMINAE

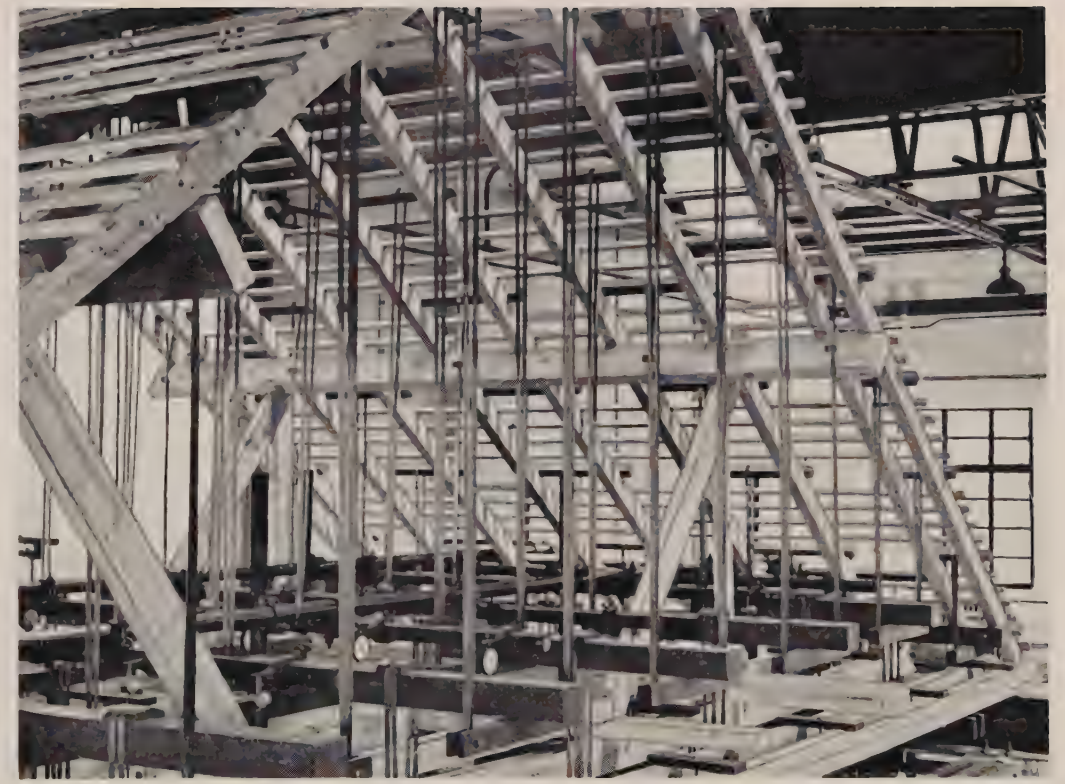
Each lamina of the wood under test is wrapped successively round cylinders of decreasing radius until failure occurs. The limiting radius is the average of a large number of tests.

PLATE 2



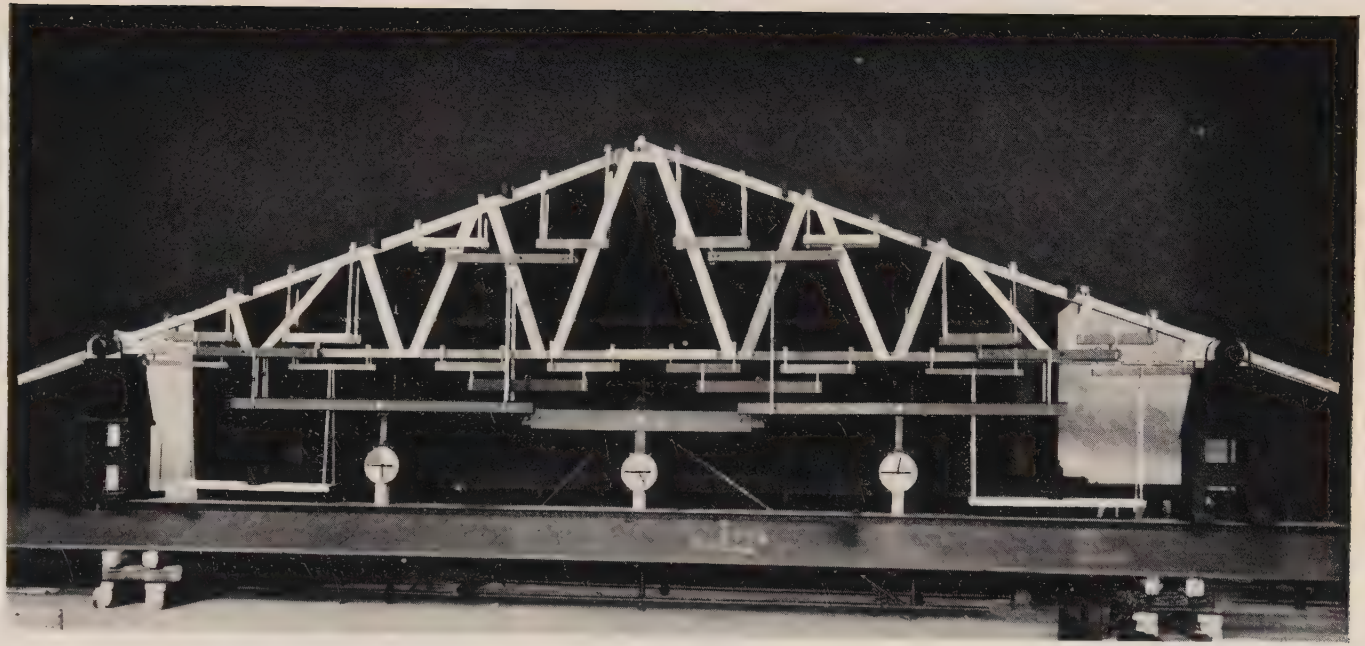
GENERAL ARRANGEMENT OF ROOF TEST

The particular roof (span 22 ft., length under test 13 ft.) exemplifies the common but unsound practice of supporting purlin struts on ceiling joists.



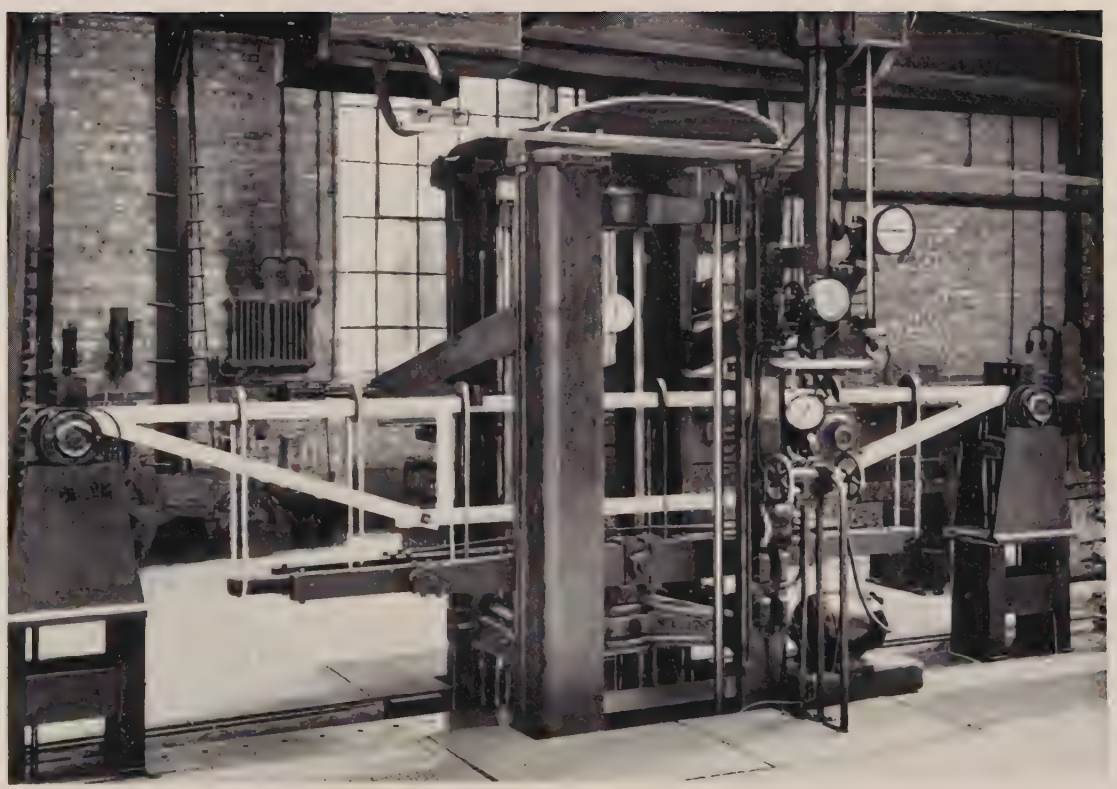
THE ARRANGEMENT OF THE UPPER PART OF THE LOADING SYSTEM IN THE ROOF TEST

PLATE 4



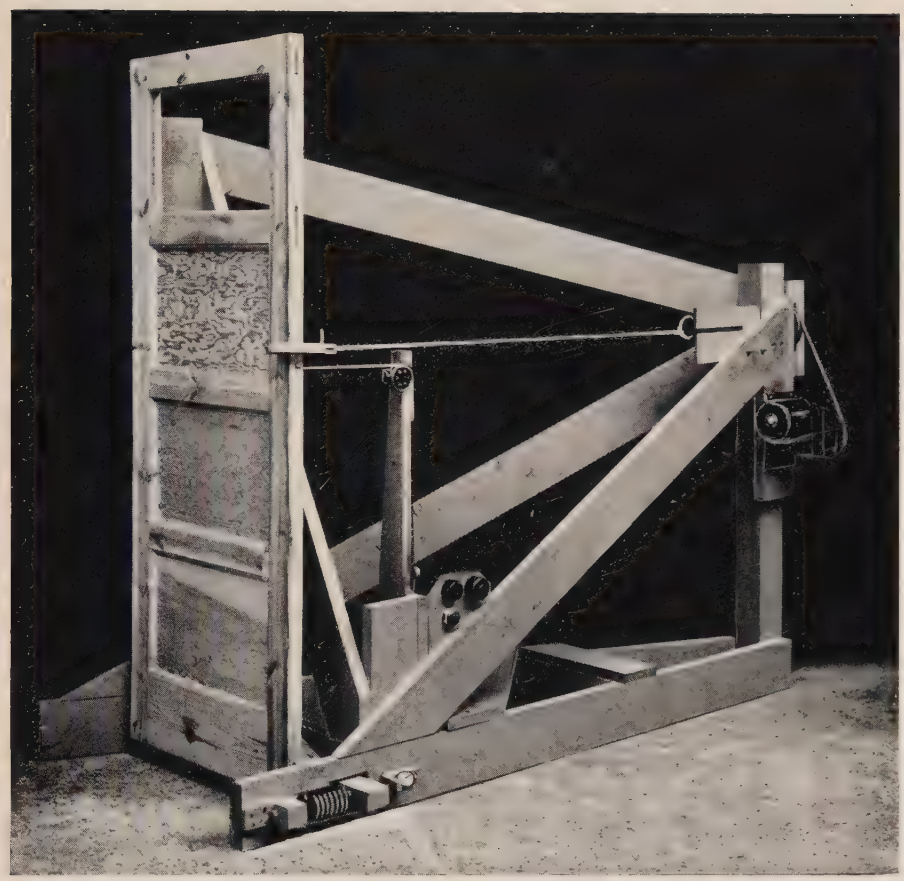
TEST ARRANGEMENT FOR A ROOF TRUSS OF 30 FT. SPAN, WITH INDEPENDENT LOADING OF RAFTERS AND CEILING JOISTS

PLATE 5



TEST ARRANGEMENT FOR A BUILT-UP PURLIN

PLATE 6

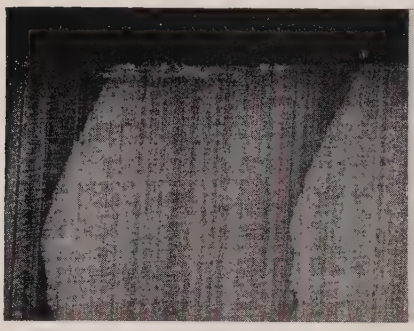


THE GENERAL ARRANGEMENT OF THE TORSION TEST FOR DOORS

PLATE 7

Rift-sawn Douglas Fir

Flat-sawn Scots Pine



Rift-sawn Yew

Rift-sawn New Zealand Matai

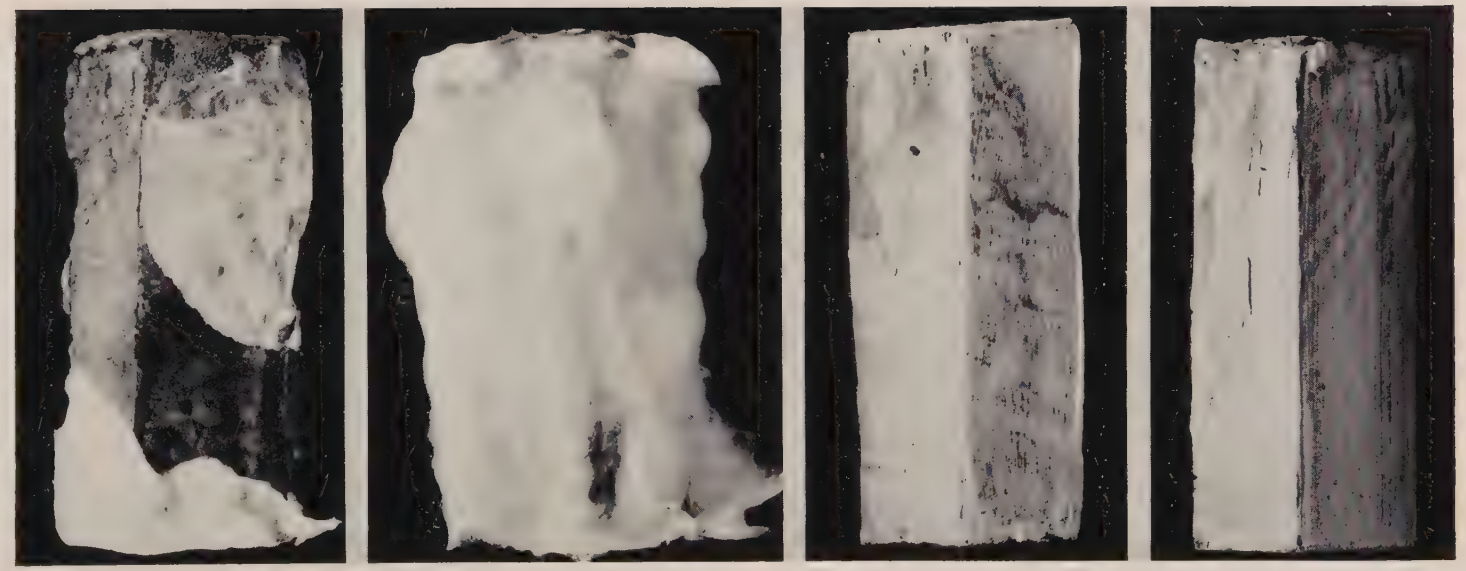
PHOTOMICROGRAPHS (× 10) SHOWING DEVELOPMENT OF SURFACE WEAR AND BREAKDOWN IN CONIFERS

PLATE 8

(A) TESTING SITE FOR NATURAL DURABILITY AT PRINCES RISBOROUGH

(B) EFFECT OF INCISING UPON SPLITTING OF RAILWAY SLEEPERS IN SERVICE
The left-hand sleeper has been incised.

PLATE 9



A B C D

ANTISEPTIC RENDERINGS APPLIED TO WOOD BLOCKS DECAYED BY *Merulius lacrymans*

A = Portland cement controls. B = Portland cement controls. C = Zinc oxychloride rendering. D = Cuprous oxide rendering.
Note the vigorous growth of fungus on A & B and its absence on C & D.

PLATE 10

(A) OAK LOGS TREATED WITH D.D.T. SPRAY AND EXPOSED TO *Lyctus* ATTACK UNDER PORTABLE COPPER-GAUZE CAGES

(B) SPRAYING UNIT WITH SPECIAL LANCE FOR THE TREATMENT OF TIMBER STACKS

PLATE 11

BEFORE

AFTER

SOFTWOOD ROOFING TIMBER ATTACKED BY THE HOUSE LONGHORN BEETLE (*Hylotrupes bajulus*), SHOWING APPEARANCE BEFORE AND AFTER CUTTING INTO INFESTED BEAM

PLATE 12

THE STRENGTH OF GLUES

Glue shear test pieces to a total of 9,151 have been pulled for laboratory assessment of plywood adhesives. A number of tests were also made for outside bodies.

BOX TESTING

Work in box testing has been limited to continuation of the proof-testing service for the control of fibreboard quality in connexion with contracts for fibreboard boxes for the export shipment of butter, on behalf of the London Offices of the Departments of Agriculture in Australia and New Zealand, together with a brief series of crushing tests of export cases early in the year for a biscuit manufacturer.

MINOR STRENGTH INVESTIGATIONS

Miscellaneous minor investigations, included work upon the strength of textile bobbins and fixings, the mechanical failure of hickory insulation for overhead trolley wires, the strength of alternative methods of corner construction for wooden boxes, the failure of ash hockey-stick heads, and the influence of certain factors involved in preparing laminated timber.

THE PLYWOOD PLANT

During 1948, the machines of the plywood-making plant have been completed by the makers and the plant is now fully operational. Work has been divided between the study of the machines themselves and of their use for assessing timbers for plywood manufacture. With the peeler, a study of the influence of knife angle and height in relation to the nose bar and spindle centres is well advanced, and some preliminary work has been done on total power consumption and the proportions absorbed by machine friction, dogging, cutting and nose bar action. By means of power-driven spools, veneer has been handled from the lathe at speeds up to 700 feet per minute, and the conveyor and clipper system for the selection of the veneer as it is unspooled has been improved and made suitable for continuous operation.

The Laboratory's dryer is of the continuous-feed breather-press type fitted with a wide range of adjustments to cope with different species and thicknesses of veneer. The relative importance of each of these adjustments is being assessed, and as this is difficult by direct methods, preliminary experiments have been made in a small steam-heated hydraulic press in which the operation of the dryer was reproduced. Contrary to expectation, it was found that most drying was effected when the hot plates were in contact with the veneer and that comparatively little took place during the breathing period. Before adopting these conditions in the dryer itself, however, the effect of such treatment on the veneer must be investigated. Steam consumption tests on the dryer have shown that it takes about 500 lb. per hour when loaded with veneer to 85 per cent of full capacity and 300 lb. per hour when empty; that is, 60 per cent is used merely to keep the machine heated. Heat quantities are being evaluated to see if this can be improved.

Experimental work—and indeed factory production—demands a rapid means of determining moisture content, and for this the instantaneously-acting electrical meter has been tried. Systematic tests have shown, however, that the degree of uncertainty with these instruments makes them unsuitable for use on newly-dried veneer even if corrections for species and thickness are known.

Other means of determining moisture contents within a few minutes are being tried, and present indications are that a modified oven-drying technique will prove satisfactory.

English beech was used for most of the testing work on the peeler and dryer, but some work on other species has been done, namely on red and white seraya, mora, morabukea and gaboon. The main problem has been to develop a system of assessing timbers for quality and yield, and, in this work, the Laboratory has received great practical help from the Plywood Research Panel, which meets at the Laboratory. The aim of the yield system is to present quantitative data in such a form that they can readily be interpreted by industrial producers even although they themselves may employ a different method of conversion. Once the system is established, new species can be tested and assessed by comparison with timbers whose characteristics have already been determined.

The operation of the doctor-roll glue spreader has been investigated and the results published. With resin adhesives, no difficulty was found in obtaining and maintaining spreads of 2–2¼ lb. per 100 square feet of single glue line, and it was shown that while the doctor rolls are a valuable adjunct to the machine, precision-construction and careful maintenance are even more necessary if low spreads are to be obtained in this or indeed in any type of spreader.

The study of glue-mixing has continued and the main principles for the efficient mixing of casein glue have been established. It has been found that immediately after dispersal of the casein glue powder in water, a mixture containing even a high concentration of the powder is very fluid, but quickly thickens as the particles swell and dissolve. It is therefore essential to remove the suspension rapidly from the centre of agitation before the increase in viscosity and other changes can interfere with the mixing of subsequent material. This leads to the necessity of mixing on a continuous basis, and a method has been developed for which a provisional patent specification has been filed. Streams of casein powder and water are directed into a rotating cup in which centrifugal forces rapidly submerge the particles. The suspension flows up the diverging walls and is flung out from the rim on to a collecting ring. The laboratory-scale model will produce casein glue at the rate of one or two pounds per minute. A modification of the apparatus has also been found effective for the mixing of a resin glue with its hardener, and both methods are being developed further.

PROPERTIES OF ADHESIVES

Results are now accruing from the several series of long-term natural-durability tests on glues, and reports have been prepared covering two or more years' exposure tests of beech plywood and on the ply-clad frames. Other experiments nearing the stage for a progress report include the tests on adhesives in lime plywood (a parallel investigation to that on beech) and on laminated beams.

The comparative trends of behaviour of the various types of glue can be indicated by extracts from the summaries of two of the reports.

1. " As the result of exposing $\frac{3}{16}$-inch beech plywood panels to the weather for two to three years on racks in open fields, complete failure has occurred with animal and casein glues and with neat and flour-extended urea resins. Boil-proof urea glues of the type employed have reached fail-point in three years. Phenolic and resorcinol adhesives remain serviceable after thirty months, but they too show incipient deterioration."

2. " With the ply-clad frames* at the end of two years, the bone-glued units are approaching complete breakdown. Degrade has occurred on those made with hide glue, normal and toxic caseins, and close-contact urea resin—generally in the order stated. The gap-filling urea glue is giving a better performance than the close-contact type, but is proving less durable than either the resorcinol or the phenolic resin, which in their turn are not without deterioration."

These findings are based on experiments that impose very severe conditions, and although the results as such are reliable, their interpretation for conditions other than those of the tests must be made with care. Under less rigorous exposures, the adhesives maintain their strength and efficiency for much longer periods and a glue unsuitable for the worst conditions may well function satisfactorily elsewhere.

Work on the preparation of plywood for testing glues in the tropics is well advanced, and an experiment upon adhesives in marine craft has been planned following a survey of many ex-naval vessels.

The Adhesive Makers' Panel continues to provide invaluable liaison between the Laboratory and industry, and is now in its fourth year. An example of its services to the Laboratory is afforded by the Panel's arranging the selection of the proprietary adhesives for use in the tropical weathering tests.

SPECIAL HEATING METHODS FOR SETTING GLUES

Radio Frequency Heating

Early in the year the work on the ' glueline method ' of heating reached the stage at which it was desirable to decide upon specific restricted investigations. In making selection the advice was sought of the Radio Frequency Panel, which held its third meeting in June. The opinion was that industry chiefly needed a means of assessing the relative merits of different glues for radio frequency work, and the behaviour of a range of glue types under glueline heating has therefore been undertaken with the aim of developing a standard test.

Previous tests had all been performed with a Sitka spruce sample resembling a portion of a laminated beam, and this sample proved very suitable for the work, but it has since been found that the species of the timber is a very influential factor, and in fact no species has been found so amenable to treatment by this process as Sitka spruce, originally chosen because of its wide use in wooden aircraft construction. With many hardwoods the glues require a voltage gradient several times as high as with spruce, and this causes a disproportionate increase in the power wasted in heating the wood substance. With a dense heartwood, such as that of oak, this development of heat may lead to scorching. It is, however, with hardwoods that potential users of the process are at present chiefly concerned, and several forms of hardwood sample are therefore being examined.

At the first meeting in 1947 of the Radio Frequency Panel attention was drawn to the lack of standard terminology in publications on radio frequency heating and the Laboratory was asked to draw up a glossary of terms covering the applications to wood. This glossary has been issued and is being circulated amongst the industries interested.

* The details of these frames were given in the Report for 1946. Briefly, they are softwood frames to which are bonded plywood sheets. These have their edges protected in various ways and each frame is exposed to the full weather on one side, and on the other to outdoor air but not to sun or rain.

Mains Voltage Heating

The application of heat for setting glues in veneering work has long been practised by industry, the operation being performed in light multi-platen presses heated by hot water. Much veneering is, however, still done without heat—a relatively slow process. In response to trade enquiries means have been developed for adapting single-daylight cold presses to hot press work at low cost, the method being to insert thin flexible electrically heated 'cauls' between successive glued assemblies in the press. The cauls are made of laminated insulating material incorporating wire-wound elements energized directly by the electric mains. The process is referred to as mains voltage heating to distinguish it from the method using a step-down transformer (low voltage heating). Such cauls can be simply and cheaply made from five sheets of thick resin-treated paper in sizes to suit specific applications. The central sheet of paper is subdivided and soft iron wire wound on the pieces, and the whole is then consolidated under heat and pressure in a manner similar to that of plywood manufacture. Firms can thus manufacture electric cauls to suit their particular requirements, although it has not yet proved practicable to make them at the low temperatures and pressures available in the ordinary veneering press. In use, a power concentration of about 600 watts per square foot has been found suitable. This causes a rapid rise to the desired working temperature, which may then be held approximately constant by reduction of power to a quarter by simple parallel-series switching. The experimental cauls were approximately 2 ft. × 1 ft. and larger sizes are in preparation to confirm the findings with the smaller ones.

PROPERTIES OF PLYWOOD

Work on the causes and prevention of cracking of ornamental veneers laid on plywood is continuing, and an article on this industrially important subject has been published. Only in special cases is trouble experienced when the veneer is laid across the grain of the plywood face, but when the grains are parallel, cracking frequently but not inevitably occurs. The latter practice is generally recognized as being unsound, but under present conditions of supply, it is sometimes unavoidable. Means of reducing the extent of the cracking that takes place under these circumstances are being sought.

SAWING AND MACHINING

A further series of experiments in ripsawing has been carried out with saws of 26-inch diameter, carrying from 20 to 80 teeth, and with feed speeds up to 100 feet per minute. The relation of tooth pitch, depth of cut and feed speed to the power required by the saw and the feed resistance has been determined for Scots pine and lime. Points of interest were that the power demand decreased as fewer teeth were used on the saw, i.e. as the pitch was increased, and a saving in power of nearly 40 per cent resulted from a reduction in the number of teeth over the whole range; and that power demand increased with the feed speed but in a relation which involved a saving in energy (kilowatt-hours per 100 square feet of cut surface) as the speed was raised. Increase in the depth of cut resulted in greater power being required and in this instance involved an increase in energy consumption.

Investigations in rotary planing have been resumed during the year, and the first experiments have been concerned with the effect of varying feed speed on the power required in cutting and the resistance to feeding, at constant spindle

speed and normal cutting angle of 30°. A somewhat similar relationship between these factors to that in ripsawing was found in planing lime, which is a useful material for this class of test owing to its uniform texture. It was found that quarter-sawn lime required 20 per cent less power than flat-sawn.

A series of tests was made in the sawing of special sheet material consisting of compressed phenolic-resin-impregnated paper. The most suitable shapes of tooth, speeds and other cutting conditions were determined. A similar investigation was undertaken upon the cutting of compressed straw blocks.

Other research work during the year has included:—Further studies of chip formation at slow speed in rotary cutting on a new type of " cutability " machine which was designed and constructed at the Laboratory; calculation of the stresses for high speeds of rotation in a special form of solid cutterhead having tungsten-carbide-tipped cutting edges; mathematical analyses in rotary planing for anti-clockwise rotation of cutterblocks below and above the wood being cut; and stroboscopic studies of cutting action in the operation of moulding.

SAWING OF REFRACTORY TIMBERS

Further work has been carried out upon methods of improving the output obtainable in converting and re-sawing timbers which have a severe blunting effect on saw teeth. These timbers may be of " woolly " character or may contain an abrasive substance such as silica. The problem has been approached in three ways, either by using extra hard saw teeth, by modifying the cutting action of the teeth, or by obtaining full advantage of the " edge-life " of normal teeth, and the following conclusions have been reached.

Wide band saws customarily have their teeth swaged and dressed to provide side clearance in the cut, though alternate spring-setting is sometimes preferred. It is not practicable, therefore, to harden the teeth of these saws, as swaging or bending sideways would not be possible. The necessary hardness can be obtained by tipping the teeth with a special steel alloy, a cobalt-chromium-tungsten alloy (Stellite) or tungsten-carbide, but the tips must be so designed that side clearance to the blade is provided throughout their life. Tungsten-carbide tips are exceedingly hard but somewhat brittle and require full support at their bases and backs to prevent breakage occurring under load. They have to be brazed to the metal of the base—a source of weakness, and in addition a special technique in sharpening is required, involving the use of resin-bonded diamond grit wheels. The cobalt-chromium-tungsten alloys can be deposited at the tooth tips by oxy-acetylene flame. Though less hard than those of carbide, they also are brittle and need to be adequately supported. Sharpening can be carried out by means of standard types of grinding wheels of appropriate grade and grit. Tips of special steel alloy if welded to the teeth should be fairly satisfactory, but would not be expected to give as good service as those mentioned above. No experiments have as yet been undertaken in this relation on band-saws, but hard-tipping of the teeth of the larger diameter inserted-tooth circular saws is now under trial. For re-sawing and for many other purposes, circular saws of diameter up to 24-inch with tungsten-carbide-tipped teeth have been available for some years and have proved successful. They are, of course, expensive and require the use of diamond wheels, with precision methods of grinding.

When operating with ordinary types of saw, the method of modifying the cutting action of the teeth may be the best means of improving results. A tooth of a circular saw or band saw cuts a kerf in the wood to a depth equal to the

product of the tooth pitch and the feed speed divided by the cutting speed of the saw. Under normal conditions, it is seldom convenient to arrange for an alteration in the spindle speed of a circular saw mill or of the saw pulleys of a bandmill, and thus the cutting speed of the saw may be considered as fixed. Similarly, the feed speed employed on the machine is chosen by the sawyer according to the class of timber, depth of cut and performance of the saw, but usually with a little bias towards the slower rates of feeding. The kerf depth per tooth depends largely therefore on the tooth pitch and as, in general, there is a tendency to use rather too many teeth on saws this depth of penetration of each tooth may be so small that a true cutting action is almost impossible and scraping may occur. Such a condition may not be particularly important in cutting timbers that do not tend to blunt teeth unduly, though the power required by the machine will then be greater than it need be. With the abrasive class of timber, a scraping or rubbing action by the teeth, instead of effective cutting, will produce very rapid blunting. A remedy thus lies in the use of fewer teeth, i.e. a longer pitch, which will increase the depth of penetration per tooth and ensure that definite cuts are being made. It is not always convenient, however, to use saws having a pitch differing from the normal, e.g. $1\frac{3}{4}$ in. for wide band saws, but the effect of double the latter pitch can be obtained, either by slightly reducing the height of alternate teeth or by suitably modifying the shape of these teeth.

A sharp tooth, when cutting effectively, is able to pass through a given thickness of material a certain large number of times before it needs re-sharpening, and the total distance covered may be termed its " edge-life " travel. Deeper penetration of the tooth into the wood occurs when the feed speed is increased, other conditions being constant, and little additional wear at the tooth-face results. The maximum output during the given " edge-life " of the teeth will be obtained therefore, if the wood is fed as fast as is practicable with the particular saw and machine employed.

GENERAL WOODWORKING STUDIES

Standard tests have been carried out to determine the working properties of the following species:—

Lapacho (*Tabebuia* sp.) from South America.
Baromalli (*Catostemma commune*) from South America.
Maho (*Sterculia pruriens*) from British Guiana.
Agba (*Gossweilerodendron balsamiferum*) from West Africa.
*Louro imanuy (*Ocotea barcellensis*) from Brazil.
*Ekki (*Lophira alata* var. *procera*) from West Africa.
(*Limited tests).

Conversion studies have been made on consignments of Scots pine, Corsican pine, Weymouth pine, beech and lime. A number of abura and odoko blanks were prepared for commercial trial as to suitability in spool manufacture.

A dynamometer for measuring feed resistance has been fitted to the special feeding apparatus, which has a speed range of 25 to 150 feet per minute and can be used in conjunction with circular saw benches, bandsawing machines, surface planers and spindle moulders. Consideration has also been given to the design of recording electrical dynamometer units.

ABRASION TESTING

The work on abrasion testing has been mainly concerned with a continuation of the studies of the development of surface wear and breakdown in flooring

timbers. A detailed examination of the behaviour of softwoods under traffic has been made and this investigation, together with the work on hardwoods reported in 1947, completes the analysis of surface wear for flooring timber in general.

Softwoods show less variation than hardwoods in their behaviour under abrasive action. In general the conifers of the north temperate zone, those with distinctive ring growth, show two types of breakdown, depending on the method of conversion. The quarter- or rift-sawn material becomes ridged or serrated on the surface, and the flat-sawn material " shells-out " or disintegrates in the large area of springwood. Both these characteristic types of breakdown vary in degree under different conditions of traffic and for different species of conifer. In addition, softwoods with indistinct growth rings prove exceptional in behaviour. Such woods, as for example those of the south temperate zone, resemble in appearance the fine-textured diffuse-porous hardwoods, and their surface wear is accordingly fairly even and typical of the more uniform type of structure for this type of hardwood. It has been shown for hardwoods[1] that anatomical structure, and in particular the arrangement, size and distribution of pores, rather than density, is the main factor influencing the resistance of the wood surface to abrasive action. With softwoods density assumes greater importance since they are less complex anatomically than hardwoods and their wood tissue is more homogeneous, and it is found that the variation between springwood and summerwood influences breakdown to an appreciable extent. The analyses of worn blocks of north temperate zone softwoods have shown that the initial compression of the springwood tracheids, the walls of which are much thinner than those of the summerwood cells, is followed by a disruption and some separation in the softer tissue of the annual rings along the summerwood zones, thus giving rise to the characteristic ridging of surface in rift-sawn material. Where the ring growth is less distinct and the structure more homogeneous there is a more even compression of the superficial layers as a whole, which results in the more even wear. The photomicrographs in Plate 8 illustrate the development of breakdown in the conifers.

The standard abrasion test for determining the suitability of timber for flooring was carried out on East African muhuhu (*Brachylaena hutchinsii*). This hardwood has been suggested as a substitute for Canadian maple for heavy-duty flooring, in particular for factory and warehouse floors, and the results of the test have confirmed a previous assessment, based on the methods recommended in the above-mentioned report, of its suitability for the purpose. A test was also carried out, on request, of a patented end-grain flooring consisting of thin cross-sections of compressed resin-coated birch twigs. This type of flooring was found to possess extremely high resistance to wear.

NATURAL DURABILITY OF WOOD

Although timber has been used for centuries for all kinds of structural work there is still surprisingly little reliable information on its durability under all conditions. It has, of course, long been known that some timbers, e.g. teak, are very durable when used under conditions favourable to decay, whereas others, such as beech, decay very rapidly. This traditional information has, however, been of a qualitative rather than a quantitative nature. In the past those woods with high natural durability have been in such great demand for

[1] ARMSTRONG, F. H. Flooring Hardwoods: Their Wear and Anatomical Structure. *For. Prod. Res. Bull.* No. **21**. (H.M.S.O., 1948. Price 1*s.* 1*d.* post free.)

external structural work that some, even before the war, were becoming very scarce and new and relatively unknown timbers were coming into use.

In view of this position it was decided in 1932 to carry out long-term field service tests at several sites to determine the natural durability of a comprehensive range of timbers. Plate 9(A) illustrates the field-testing site at the Laboratory. Although these tests are not yet complete, it has been considered that the results so far obtained are of sufficient practical value to be made available[1] at the present time when the general shortage and high cost of timber demand that it should be used to the best advantage and with the utmost economy. These results, from the tests after 15 years, have been used to classify about 100 species of home-grown and imported hardwoods and softwoods, enabling recommendations to be made regarding the conditions under which they can be safely used in an untreated state and when they require some form of preservative treatment. In general the results confirm the traditional information, but there is also an indication that with some timbers soil conditions have a considerable influence on the natural durability.

MINING TIMBERS

Last year's report described the concluding results on the investigation into the preservative treatment of mining timbers. The final report has now been prepared[2].

THE PRESERVATION OF RAILWAY SLEEPERS

The experimental sleepers which were put under test in main line tracks of the four railway companies in 1935 were again inspected during the year.

The objects of this investigation are to find (1) the most efficient process for pressure-creosoting railway sleepers, (2) whether there was any advantage in using a creosote-fuel oil mixture in place of ordinary creosote under the conditions prevailing in this country, and (3) the suitability of some home-grown timbers for use as sleepers.

After thirteen years' service all the pressure-creosoted softwood sleepers appear to be free from any decay and there is as yet very little evidence to indicate which of the preservative treatments under investigation are most effective. With the exception of one group, they are, however, showing appreciable mechanical degrade which consists mainly of splitting. An analysis of this reveals that incising before treatment greatly reduces splitting (Plate 9(B)), and that splitting also appears to be influenced by whether the sleepers are laid heart-face up or down, and by the method of fixing the chairs.

The results have also shown that the usual method of creosoting as used for Baltic redwood sleepers is far from adequate for the preservation of an absorbent timber such as beech, which must be completely penetrated to obtain full protection against decay. These results confirm that other timbers, such as maritime and Corsican pine, which contain a large proportion of permeable sapwood will also require impregnation much heavier than the normal if they are to give long service in the track.

[1] SMITH, D. N. The Natural Durability of Timber. *For. Prod. Res. Rec.* No. **30.** (H.M.S.O., 1949. Price 7*d.* post free.)

[2] BRYAN, J., and RICHARDSON, N. A. Experiments on the Preservation of Mine Timber. *For. Prod. Res. Rec.* No. 3. (Revised edition). (H.M.S.O., 1949. Price 7*d.* post free.)

MARINE TIMBERS

Service tests on the durability of various species of timber used for piling and other marine work which had been in progress at Dover Harbour for 15 years were concluded in 1948. These tests confirmed the high natural durability of certain species such as okan and pyinkado, but also showed that well creosoted softwood was quite as durable.

In co-operation with the Sea Action Committee of the Institution of Civil Engineers, a scheme has been prepared and samples treated for some limited tests on methods of preserving marine timbers. The scheme provides for the exposure in the sea of pressure-treated, incised Douglas fir samples at Singapore, Colombo and at a site in the River Medway.

IMPREGNATION OF TIMBER

Routine tests to evaluate the permeability of a number of timbers now being imported have been carried out.

The satisfactory preservative treatment of some structural timbers, such as Douglas fir and western hemlock, still presents considerable difficulty and an investigation has been started to find the most effective means of injecting preservative liquids into these timbers. With oil preservatives it has been found that high oil temperatures facilitate penetration into Douglas fir and the practical limits of this effect are being explored.

FIRE RESISTANCE OF TIMBER

Studies have been continued on the inflammability and ignition of timber and the factors influencing these. It has been found that though the moisture content of the timber has a pronounced influence on its inflammability, the effect is a complex one and is not the same under different conditions of ignition.

MISCELLANEOUS WORK ON PRESERVATION

Much advice has been given throughout the year on the preservation of various kinds of timber and timber equipment intended for use in parts of the Commonwealth, and particularly in connexion with the East African groundnut scheme.

Fresh examples of the premature failure of pressure-treated timber in service have been brought to the notice of the Laboratory. Examination of all these has shown that the original creosoting had not been carried out satisfactorily. Usually this was because of inadequate seasoning of the timber before creosoting. That not a single instance of failure of properly creosoted timber has yet been brought to our notice emphasizes the crucial importance of maintaining consistently good standards in pressure-creosoting practice.

MYCOLOGICAL COLLECTION

Some field work has been done locally and in Northern Ireland, and new isolations have been added to the collection of standard cultures. New cultures have also been received from Canada and the Argentine. Numerous subcultures have been sent on request to research institutes and industrial firms in the United Kingdom and abroad.

Additions to the herbarium of sporophores of wood-rotting fungi and of typical decays have been received from Mauritius, Nyasaland and Portugal.

A room has been fitted up as a museum for the display and storage of specimens for teaching and demonstration purposes, and parties of visitors are now

able to see the work of the Mycology Section without disturbing work proceeding in the research laboratories.

PHYSIOLOGY OF WOOD-DESTROYING FUNGI

Lack of knowledge as to the length of time for which wood-rotting fungi can remain alive in a dormant condition in air-dry wood led to the setting up, in 1943, of a series of experiments with different species, which is continuing. Blocks of wood infected with various fungi have been kept in constant humidity rooms maintained at 25°C., and sub-cultures have been made from the wood at intervals. Some species died out after a few years, others—in particular *Lenzites* species—were alive after 4½ years in wood at 12 per cent moisture content. A report is in preparation summarizing the results so far obtained. The practical implications of this investigation are that once timber has been infected with wood-destroying fungi no amount of air-drying can be depended upon to kill the organisms present, and if such wood is to be used in any situation where it may become damp, as in a boat or a vehicle, it must first be sterilized by heat or preservative treatment. The sudden appearance of dry rot in houses following flooding with water can probably be sometimes attributed also to the revivification of fungal mycelium that has persisted in a dormant condition for many years from a previous outbreak that had not been completely eradicated.

Investigations of the metabolic products of lignicolous fungi are continuing in co-operation with Professor Raistrick's department of the London School of Hygiene and Tropical Medicine. The products formed by *Polyporus benzoinus* in culture are being studied further. It had been observed that cultures of several species of *Endoconidiophora* produce an odour of " pear drops ", and the ester responsible has been identified as isobutyl acetate, and a second more complex product, probably methyl heptenone, has also been recognized.

LABORATORY TESTING OF WOOD PRESERVATIVES

The demand for standard tests on proprietary wood preservatives continues and a number of products have been tested on behalf of their manufacturers. Considerable interest is now being shown in preservatives based on pentachlorphenol, and several products containing various formulations of this compound have been examined. Provided that sufficient pentachlorphenol is present, such formulations are effective.

As reported last year, it is proposed to test the toxicity to wood-rotting fungi of a number of volatile compounds that might be used for the sterilization *in situ* of large built-in timbers that may be slightly infected with dry rot, and whose replacement would be extremely costly. A number of compounds has been tested on agar cultures and found to be effective in a saturated atmosphere. An apparatus has been devised by means of which various dilutions of these vapours can be obtained, so that their toxicity can be determined. It will also be necessary to study the degree to which such vapours can diffuse in wood.

LABORATORY TESTS ON DECAY RESISTANCE OF TIMBERS AND OTHER BUILDING MATERIALS

Standard laboratory tests on the resistance to decay of the following timbers have been completed:—

danta, douka, olon, gaboon, mubura, landosan.

In some species of trees, such as western red cedar, there is considerable variation in resistance to decay in different parts of the heartwood. From a

preliminary experiment on Scots pine indications have been obtained that the resistance may be higher in the outer heartwood than it is at the centre. Further tests on this species and other timbers are planned. If this phenomenon is of general occurrence, it will mean that selection of samples for tests of their natural durability will have to take into account the position in the tree from which they were cut. Tests on variation in decay resistance within a single log of ' Rhodesian teak ' will be carried out when suitable test fungi capable of causing losses in weight in this extremely durable species have been found.

Samples of a number of different kinds of wallboard have been received from the Building Research Station for test against dry rot fungi.

DRY ROT IN BUILDINGS

Dry rot continues to be extremely common, particularly in buildings which were left unoccupied during the war or which received bomb damage. Very often this dry rot does not become apparent until the building is re-occupied, and the rot becomes evident only after the timber is dried and excessive shrinkage occurs, revealing its decayed condition. In houses where an active attack by *Merulius lacrymans* has occurred the fungus is usually found to have penetrated deeply into the brickwork; sometimes the cavity in a hollow wall may be filled with mycelium.

Superficial sterilization of such infected walls does not always prevent the fungus growing out again if dampness persists in the wall, and a rendering that would effectively prevent fungus growths emerging from the wall would be very useful. In co-operation with the Building Research Station zinc oxychloride renderings have been prepared that have given very promising results. No growth of *Merulius* was able to penetrate a rendering of this material applied to blocks in which the fungus was growing actively (Plate 10). Renderings of ordinary Portland cement were readily penetrated by the fungal strands and, after a short time, became softened and fell to powder, presumably as a result of the acids produced by the vigorous growth of the fungus in the wood.

Cultures of *Merulius lacrymans* were supplied to an investigator who wished to test the effect of X-rays on this fungus. It was found that the fungus was unaffected by very heavy doses of X-rays.

SAP-STAIN OF WOOD

One of the major obstacles to the successful exploitation of light-coloured hardwoods from tropical regions is their susceptivity to sap-stain. Whenever samples of stained timber are received at the Laboratory, the fungi present are examined and cultures are prepared if possible. The staining fungus that has been found most commonly is *Diplodia* species, possibly *D. natalensis*. This fungus was found to be responsible for extensive staining in several consignments of Venezuelan boxwood imported for the manufacture of rulers, a purpose for which clean bright wood is necessary. It is likely that the logs were infected with this fungus before shipment and the application of an antiseptic immediately after felling would seem to be desirable in future in order to prevent the trouble. Boxwood must always be dried slowly to avoid splitting, and therefore the timber remains in a condition susceptible to blue stain for a longer period than with timbers which can be dried more quickly.

ROT OF WOODWORK IN BOATS

Many wooden vessels which were constructed during the war have now been

adapted for other purposes and, during alterations, decay has been discovered in the woodwork in many of them. Some of this can be attributed to the general lack of maintenance that the vessels have received since the end of the war, and to the absence of any provision for ventilating the bilge spaces. Extensive decay in birch plywood bonded with urea formaldehyde resin, used for frames, has been found in a number of vessels. This timber is not resistant to decay and should always receive preservative treatment when employed in damp situations, whether as plywood or as solid timber. The presence of a glue resistant to micro-organisms cannot protect the wooden veneers in plywood against decay. Frequently, also, decay has been found to have penetrated through the unpainted edges of the plywood, destroying the central veneers and leaving more or less undamaged the outer veneers that are protected on the face by a film of paint.

ISOLATION OF A SAPONIN FROM THE WOOD OF THE MORA TREE (*Mora excelsa*)

In the course of a chemical examination carried out on behalf of the Colonial Products Research Council of the wood of *Mora excelsa* from British Guiana, the heartwood of several samples was found to contain an unusually high proportion of material soluble in water. Approximately one-half (eight to ten per cent of the original heartwood) of this soluble material was identified as a saponin. Heartwood of the same species grown in Trinidad, and of the closely related species morabukea (*Mora gonggrijpii*), has also been found to contain saponin. So far as mora wood is concerned, sufficient information has been obtained to show that the saponin content is variable, being as low as 3·5 per cent in some samples. Saponins have previously been found to occur in small amounts in the boles of a few tree species[1] but, with proper selection of material, mora heartwood may prove to be a relatively rich source.

Mora saponin has excellent foaming properties over a pH range of 3·00–10·00. On hydrolysis with 6 per cent alcoholic HCl it breaks down into (a) a mixture of glucose and xylose, and (b) a complex mixture of sapogenins. One of these sapogenins has been obtained in crystalline form and in 9·4 per cent yield (based on saponin). Preliminary investigation has indicated the following properties for this substance: melting point 261–263°C., $[\alpha]_D^{20°}$ + 16·8° (c = 1·09, in acetone), molecular weight by Rast's method, 398 (approximately). Found C,76·67:H,10·66. The acetate of the sapogenin had melting point 245·5–246·5°C. and $[\alpha]_D^{20°}$ + 29·3° (c = 0·97, in acetone). Found for the acetate C,76·3:H,9·9. Definite evidence as to whether the sapogenin is of the triterpenoid or steroid type is being sought and attempts are being made to isolate further pure products from the saponin hydrolysate.

THE STARCH AND RELATED POLYSACCHARIDES OF CERTAIN HARDWOODS

In continuation of previous work on wood starch[2], which has been in abeyance since 1939, a method has been evolved for isolating starch grains from certain hardwoods with a minimum of chemical treatment. Suspensions of air-dry 20–60-mesh sapwood sawdust in water were agitated with a high-speed propeller-type stirrer for approximately 45 minutes in order to dislodge the starch

[1] WISE, L. E., *et al.* *Wood Chemistry.* (Reinhold, New York, 1944 (p. 436)).

[2] CAMPBELL, W. G. Starch and Related Polysaccharides of Certain Hardwoods. 1. The Preparation and Properties of Oak and Walnut Starch. *Biochem. J.*, 1935, **29.** 1068-1080.

grains from open parenchyma cells. Subsequent filtration through a Jena G.1 sintered glass filter was effective in retaining the larger wood particles and allowing the starch grains to pass through in suspension in the water along with a proportion of fine wood particles. Each suspension obtained in this way was allowed to settle and the greater part of the supernatant water was decanted. The combined yields from several batches of the original wood were then agitated with an excess of fresh water and allowed to settle. Wood particles larger than the starch grains settled out first and when the suspension as a whole appeared free of wood (as determined by frequent examination of pipetted samples of suspension under the microscope) it was siphoned from the sediment and set aside to allow the grains to settle. This process of agitating with water, settling and siphoning was repeated several times until all wood particles which settled more quickly than starch grains were removed.

After final settling from suspension in water, the starch grains were washed with acetone to remove soluble colouring matter and water. They were then collected on a silk filter, washed with ether and air-dried. Typical yields (as a percentage of oven-dry original wood) of granular starch obtained in this way were: 1·2 per cent from oak sapwood (*Quercus* species), 0·075 per cent from maple wood (*Acer* species), and 0·16 per cent from elm sapwood (*Ulmus campestris*). The grains were buff-coloured owing to the occlusion of tannin or other colouring matter which could not be removed by cold solvents but could be removed by mild chlorination followed by washing with dilute aqueous sodium sulphite. The oak starch prepared in this way contained about 8–10 per cent of impurity consisting for the most part of finely divided wood fibre and had $[\alpha]_D^{20°}$ + 154·8° in N/1 NaOH (c = 0·47). The ash content was 0·16 per cent. The unbleached starch grains from elm wood had $[\alpha]_D^{20°}$ + 149° in 0·5N NaOH and contained approximately 7 per cent of impurity insoluble in perchloric acid.

These starches are under investigation in the Chemistry Department of the University of Edinburgh under the direction of Professor E. L. Hirst, F.R.S. Preliminary investigation shows that the impurities they contain consist in part, at least, of glycosides, which interfere with the normal methods of determining molecular chain lengths, and amylose contents so that further work will be required before the constitution of wood starch is known. It can now be concluded with certainty, however, that the uronic acid complexes originally found[1] in the starch isolated from wood after solubilizing in hot water were impurities derived from cell-wall polysaccharides. CO_2 estimations carried out on oak starch grains gave results of less than 0·5 per cent, which, in accordance with previous findings[2], is without structural significance.

MISCELLANEOUS CHEMICAL WORK

Problems involving the corrosion of metals by wood, the construction of chemical vats in timber, and the eradication of stains from floors, etc., continue to figure largely in the miscellaneous work. The less conventional inquiries show the usual remarkable range of subjects as diverse as fire-lighters, slide-rules, and exudations from wooden heels.

[1] Campbell, W. G. Starch and Related Polysaccharides of Certain Hardwoods. 1. The Preparation and Properties of Oak and Walnut Starch. *Biochem. J.*, 1935, **29**, 1068-1080.

[2] Campbell, W. G., Hirst, E. L., and Young, G. T. Estimation of Uronic Anhydride Residues in Polysaccharides. *Nature*, 1938, **142**, 912-913.

THE CONTROL OF *Lyctus* POWDER-POST BEETLES

With the publication of the Laboratory's recommendations[1] for the preventive spraying of stacked timber against infestation by *Lyctus*, a point has been reached at which it is convenient to make a brief retrospect of the history of the campaign against this pest, particularly as it reflects the work of the Laboratory during the last 20 years.

Lyctus powder-post beetles are common pests of the sapwood of many hardwoods in most parts of the world. Nearly 25 years ago, in 1925, the importance of these insects and the need for development of methods of control were first realized in this country by manufacturers using hardwoods, chiefly American oak, elm, walnut and some other susceptible timbers, but very little was then known of their habits and the details of their biology. At the request of a group of furniture manufacturers in High Wycombe, a localized investigation was started on their behalf in the beginning of 1926 but was soon developed to cover the country as a whole, and, indeed, formed one of the first extensive contacts between the timber and allied trades and the recently established Forest Products Research Laboratory. Intensive research was continued at Princes Risborough during the 12 years before the war and provided detailed information upon the biology of the insect, and at the same time led to improved methods of control which enabled the more progressive firms to keep their losses at a minimum by modifying their practices of handling, storing, or treating their stocks. These early investigations, the results of which have been published in scientific and technical journals, stimulated work on *Lyctus* in other parts of the Commonwealth, notably in Australia where these insects are important pests of native hardwoods and where the problems presented by infestation have, to a large extent, now been overcome by the adoption on a commercial scale of remedial measures developed to meet requirements in that country.

In Great Britain, however, similar problems have not yet been completely solved, and the reason for this is not difficult to find. In the first place, before the war, trouble from *Lyctus* was usually due to the importation of infested timber, and control measures were therefore aimed primarily at eradication of attack before the timber passed into use. Heat sterilization schedules[2] were developed and have been widely used by firms possessing the necessary kiln facilities. The need for a cheap and easily applied insecticide treatment for preventing attack was not at that time a vital necessity. It is of interest to compare this situation with conditions in Australia where permanent protection of the wide band of sapwood in many native timbers, including secondary species, was required and has led to the extensive use of boric acid for the treatment of veneers and, more recently, of solid timber. Such treatments, of great economic value as they are in Australia, are not generally applicable in the United Kingdom. Furthermore, in spite of greatly increased knowledge of the biology of *Lyctus* and of the conditions which determine the susceptibility of sapwood to attack, satisfactory control of the insect throughout the country had not been achieved at the outbreak of war in 1939. Individual firms sometimes took action but co-operative efforts—very nearly achieved on more than one occasion as a result of trade discussions—never actually materialized. There had developed, however, at that time widespread realization of the importance of

[1] D.D.T. Spray Treatment for Prevention of *Lyctus* Attack. *For. Prod. Res. Leafl.* No. **43**, 1948. (Gratis from the Laboratory.)

[2] The Kiln Sterilization of *Lyctus*-infested Timber. *For. Prod. Res. Leafl.* No. **13**, 1937. (Gratis from the Laboratory.)

Lyctus infestation, and an increasing number of complaints of its presence in imported hardwoods has led to an intensification of work on prevention of attack in the United States.

Such was the general position in 1939 when interest in *Lyctus* and other wood-boring insects was naturally overshadowed by more pressing problems. This neglect—temporary, it was hoped—of an important insect pest unfortunately continued and has been directly responsible for the trouble now experienced with infestation in manufactured articles. During the war, when national stocks of hardwoods were stored on dispersal sites and wharfingers' premises in many parts of the country, ideal conditions were provided for a large increase in the population of the insect, especially in the absence of any preventive treatments. These stocks, including quantities of home-grown oak, felled at all times of the year, converted and stacked for seasoning, furnished particularly suitable breeding grounds for the insect. These conditions were foreseen[1] and remedial measures advised by the Laboratory early in the war, and in 1942 Timber Control asked the Laboratory to undertake a survey of the national stocks of hardwoods to obtain information on their condition with regard to insect attack. This investigation, which covered timber storage sites in England and Scotland, revealed widespread infestation and pointed to a further increase in damage and serious trouble for manufacturers when the attacked timber was put into use.

About the same time, the utility furniture scheme came into operation and it soon became evident that infestation not obvious at the time of manufacture would be found in manufactured goods within a few months, and the problem was recognized as more serious than had been realized during the storage of the timber. The general scarcity of wood and the impracticability of eliminating sapwood, which alone is susceptible to infestation, aggravated the position. As a result, there arose for the first time in this country an urgent need to devise a simple and cheap treatment for green timber to protect it from *Lyctus* attack during seasoning. The comparatively narrow band of sapwood in English oak, the timber chiefly concerned, and the cost and time required for impregnation treatments, even if facilities had been available, did not justify the use of boric acid, so successfully developed in Australia. A superficial treatment to give temporary protection only, during seasoning and storage, was considered sufficient as an immediate means of arresting spread of infestation. Spraying with proprietary insecticides had been used for this purpose by individual firms but had proved much too costly and unsuitable for application on a large scale. Immersion of green timber straight from the saw in a 5 per cent hot water solution (180°F.) of borax for at least one minute was shown from experimental work at the Laboratory to be effective and seemed to offer practical possibilities. The need to use a hot solution applied as soon after cutting as possible, before drying had started, and the cost of the special handling of the wood, were, however, amongst the objections raised to such a control measure which, except by a few individual firms, was not generally adopted. Recent experiments at the Laboratory have, however, shown that even a cold dipping treatment of green timber in a 5 per cent solution of borax will greatly reduce, but not entirely prevent, infestation in sawn lumber stored out-of-doors or under cover.

There still remained, therefore, the need for some other form of treatment which could be applied to stacks of timber, either green or seasoned, to prevent

[1] FISHER, R. C. Damage by Timber Insects in War-time. *Timb. Tr. J.*, 1941, **156,** 406; *Timb. Plywood,* 1941, **80,** 370.

infestation by *Lyctus*. The new insecticides, D.D.T. and Gammexane, offered possibilities but although these preparations had been shown to be effective for the control of a wide range of agricultural, household and other insects, which are killed by coming into contact with them, or by walking over surfaces upon which they are present, little or no information was available in relation to wood-borers; their effect on *Lyctus* was entirely unknown. Accordingly, in 1945 a series of preliminary experiments was started on a laboratory scale and the results soon showed that, in common with other wood-borers used in these tests, *Lyctus* was affected in the same way as many other insects, and an extension of this preliminary investigation was therefore justified. A comprehensive series of experiments was set up in 1946 to find out whether the sapwood of English oak in the form of converted boards, piled as in logs, could be protected from *Lyctus* attack by spray treatments. The work was planned on a semi-commercial scale and natural infestation of the timber, which included untreated controls, was supplemented by the addition of numbers of *Lyctus brunneus* beetles to large cages in which the timber was confined for part of the summer (Plate 11(A)). Subsequently, the cages were removed and the timber remained out-of-doors without any protection from the weather.

The results of the treatments were determined by detailed examination of individual boards, a search being made for signs of attack in the form of larval tunnels and, in due course, exit holes. At the same time, the starch content of the boards, treated and untreated, was estimated by the iodine-potassium iodide test to confirm that the timber was suitable for normal infestation by *Lyctus*. Indications of the value of the treatments first became available early in 1947, but it was not until May 1948 that they were considered sufficiently promising to warrant a general recommendation for the use of D.D.T. to give temporary protection of timber from *Lyctus* attack. The suitability of the recommended treatment for application on a full commercial scale was determined with the co-operation of two furniture manufacturers of High Wycombe, who arranged trial spraying of stocks on commercial premises. Details of the treatment as at present advised have been published[1][2] and an account of the work was broadcast in the Overseas Service of the B.B.C. in August 1948, in view of its interest to other countries in which *Lyctus* and related powder-post beetles are important pests of timber.

It is opportune, however, to summarize the recommendations, underlining one or two points which are of special importance. D.D.T., which is insoluble in water, is available in various types of formulation. The tests at the Laboratory have been undertaken with a kerosene solution and with a water emulsion made up from a miscible oil concentrate; different concentrations of D.D.T. have been used in these formulations. Although good results have been obtained with both, the recommendation made by the Laboratory at present, is for the use of a 2 per cent emulsion in water. This spray can be prepared from miscible oil concentrates in solvent naphtha or xylene containing 20–25 per cent, or some other specified amount of D.D.T., by dilution with the required amount of water. Suitable concentrates are available from a number of insecticide manufacturers. The resulting milky fluid is a stable emulsion which will not discolour or affect the working or finishing properties of the timber to which it is

[1] D.D.T. Spray Treatment for the Prevention of *Lyctus* attack. *For. Prod. Res. Leafl.* No. **43**, 1948. (Gratis from the Laboratory.)

[2] FISHER, R. C. D.D.T. and Control of *Lyctus* Powder-Post Beetles. *Emp. For. Rev.*, 1948, **27** (2), 303-305.

applied. Treatment consists of spraying so as to ensure complete covering of all sapwood in existing stocks of susceptible hardwoods, e.g. oak, ash, elm (beech and birch are immune from *Lyctus* attack and do not require treatment). Since sapwood alone is liable to infestation, heartwood need not be treated. Experience has shown that for large quantities of timber, the spray can best be applied by using a small compressor (Plate 11(B)) operated in combination with a long spray lance enabling the more inaccessible parts of timber piles easily to be reached. For smaller quantities of timber, a hand-operated sprayer of the type commonly used in horticulture should be adequate, but a modified type of lance is advisable to ensure that the spray will reach the whole of the sapwood.

This treatment is suitable for applying to green or seasoned stocks and, for timber stored out-of-doors, should be given not later than the beginning of May, preferably earlier after a mild winter, so that it may be protected before *Lyctus* beetles emerge from attacked wood in the early summer and attempt to spread infestation by laying their eggs in untreated sapwood. It is not yet known how long a single treatment given at such a time will remain effective, but there have been indications from the work so far undertaken at the Laboratory that it is likely to be sufficient to protect timber throughout the summer, covering the complete emergence period of the beetle. Re-sawing or machining of treated boards will remove the superficial deposit of D.D.T. and, if this happens, re-spraying will of course be necessary to ensure continued protection, which is dependent upon contact of the insects with the insecticide.

Such a treatment has been recommended primarily as a preventive and not for general use on timber already infested by *Lyctus*. Heat sterilization in a kiln is the only practical and reliable remedy in such cases, but where kiln facilities are not available, the D.D.T. spray will at least prevent re-infestation. Furthermore, experiments have shown that it will restrict but not entirely prevent emergence of beetles from infested timber. It cannot be expected to destroy larvae already boring within the wood and not reached by the surface deposit.

Costing figures have shown the treatment to be on a sound economic basis, and one firm has estimated that if they can reduce their wastage of sapwood by as little as ¼ per cent the saving will pay for the cost of spraying. This simple treatment thus offers not only furniture manufacturers with stocks of timber stored on their premises, but also merchants, wharfingers and importers, a readily applied means of preventing spread of infestation by *Lyctus*. During 1948 there have been indications that the furniture industry will adopt the treatment on a large scale; it remains for the hardwood timber industry in general to follow suit.

In the meantime, research is being continued at the Laboratory with lower concentrations of D.D.T., and with Gammexane. It is especially worthy of note that first results of experiments started in 1947 with the Gammexane dispersible powder, P. 530, now marketed as P. 520, made up in the form of a suspension in water, are particularly promising. Alternative methods of applying the insecticides are also being studied. In May 1948 an experiment was undertaken to investigate the possibility of protecting piles of commercial size of *Lyctus*-susceptible English oak by applying D.D.T. in the form of a deposit from an insecticidal fog, generated by a commercial applicator of proprietary design. Experimental samples had been inserted within the piles and were subsequently exposed to infestation by *Lyctus* at the Laboratory. The results of the experiment, which is being continued and extended, are not yet available.

KILN STERILIZATION AGAINST *Lyctus*

It has been noted above that heat sterilization in a kiln is still the most effective means of dealing with an already established infestation, particularly in imported timber. During the year, reports of apparent failure of the schedules of treatment recommended by the Laboratory led to a short investigation in co-operation with a firm of furniture manufacturers. The results of this work showed that failure may occur when the required conditions of temperature and relative humidity are not obtained in all parts of the kiln. Methods of piling, especially when dimension stock is concerned, were found to affect air circulation and uniform distribution of the lethal conditions within the kiln, thus re-emphasizing the necessity of care in their management.

INVESTIGATIONS ON THE COMMON FURNITURE BEETLE, *Anobium punctatum*

Research has now been re-started on the biology of the common furniture beetle, which continues to be the most frequent cause of insect damage to old furniture, plywood, structural timbers and joinery work in buildings and is well known as a most troublesome household pest. Although of such common occurrence, details of the biology of this insect and of the conditions which determine the liability of wood to attack and govern the progress of infestation under conditions in this country are not completely known. As a basis for the development of improved methods of prevention and control, a comprehensive series of experiments was begun during the year to investigate some of the more important aspects of the biology of the pest. Special attention has been given to designing an improved type of rearing cage made from a plastic material and particularly suitable for laboratory studies of this and other wood-boring insects. The provision of suitable surfaces for egg-laying has always presented a serious difficulty in laboratory investigations on the common furniture beetle. Workers on this insect in New Zealand have developed a special technique to ensure infestation of experimental samples. Their method has been used in the work recently started at Princes Risborough and consists of winding a few strands of cotton around the sample to be infested, then tightly wrapping muslin of fine mesh over this and round the sample, securing it in position with starch paste as an adhesive. It has been found that, although the muslin facilitates egg-laying, there is a tendency for a proportion of newly emerged larvae to behave abnormally, delaying their entry into the wood by tunnelling superficially beneath the cotton threads. It is evident that the method is not altogether satisfactory and may require modification in future work.

The investigations started in 1948 include preliminary work upon the effect of fungal decay in wood on the rate of development of the larvae and, consequently, upon the length of life-cycle of the insect, and is of particular interest for comparison with the results obtained in similar work carried out before the war on the closely related death-watch beetle, *Xestobium rufovillosum*. Experiments are also now in progress to investigate the comparative susceptibility to attack of plywood made up with different types of adhesive, e.g. animal glue, blood albumin and synthetic resins. These investigations have an added interest as likely to provide information of value for more detailed studies of the nutritional requirements of the larvae.

In the course of the increasing volume of advisory work on the common furniture beetle, the Laboratory undertook during the year a special investigation to enquire into the value of fumigation with hydrocyanic acid gas for the control

of widespread infestation by this insect in large stocks of laminated wood blocks stored on commercial premises.

PREVENTION OF INSECT ATTACK IN PLYWOOD

It is common knowledge that certain types of plywood, particularly the cheaper grades made up with animal glues, are frequently severely attacked by the common furniture beetle and that a simple means of preventing infestation would have widespread application. In this connexion, an investigation has been started to determine whether the addition of D.D.T. or Gammexane to the glue lines of plywood would prevent attack. Owing to the lack of complete information on the biology of this beetle, it has not been possible to use this insect for the work, but a series of experiments has been undertaken with *Lyctus* powder-post beetles. Test samples of plywood and laminated wood, made up from the sapwood of English oak and animal glues to which 1 per cent D.D.T. or 1 per cent Gammexane was added, have been exposed to infestation by these insects. The work is as yet incomplete, but the results so far obtained show that samples containing Gammexane and exposed to attack one month after their preparation remained free from infestation. No information is available as to how long the treatment will remain effective. Material made up with glues containing D.D.T. became attacked but the extent of infestation was appreciably less than that in untreated control samples.

THE DEATH-WATCH BEETLE, *Xestobium rufovillosum*

No experimental work has been undertaken during the year with this insect but numerous inspections of buildings on behalf of architects and church authorities have been carried out. The Laboratory has again been consulted by the Ministry of Works, Ancient Monuments Branch, about insecticide treatments for the roofing timbers of Westminster Hall.

THE HOUSE LONGHORN BEETLE, *Hylotrupes bajulus*

The house longhorn beetle has long been known to occur in this country but hitherto has not been regarded as an important timber pest. In the Baltic countries, notably in North Germany, Denmark and Sweden, it is responsible for serious damage to the sapwood of softwood building timbers and is a well known pest of such structural woodwork in houses; more recently it has given considerable trouble in buildings in parts of South Africa. Reports have appeared during the year in the daily and technical press of extensive damage by this insect to timber in houses in many parts of this country. Though these indications of widespread infestation are not confirmed by the records kept at the Laboratory of infestation of timber by this and other wood-boring insects throughout the country, there have, in fact, during the last few years, been an unusual number of instances of severe damage (Plate 12) by the house longhorn beetle in localized areas in Surrey. The Laboratory has been consulted about this outbreak and has maintained close contact with the authorities in the areas concerned.

The origin and rate of spread of these recent occurrences are not fully known and it is with the object of obtaining additional information on these important points, as well as of ensuring application of the most efficient methods of control, that particular attention is being given by the laboratory, acting in co-operation with the Ministry of Health and the authorities directly concerned, to all instances of infestation that come to its notice.

A note[1] has been prepared upon the present status of the insect in this country, and to obtain information on the latest developments in methods of control was among the objects of the visit by a member of the Entomology Section to Denmark and Sweden.

INSECT ATTACK IN TROPICAL HARDWOODS

Enquiries have continued to be received upon methods of preventing insect damage, particularly defects caused by pinhole borers, in hardwoods from the tropics. The need for a full-scale investigation of the problem in the colonies, especially in West Africa, has been repeatedly stressed by the Laboratory as the only satisfactory means of seeking a solution and of determining to what extent control measures, suitable for application in commercial practice, can be developed. In the meantime, experiments have been continued in the Gold Coast, Malayan Union and British Honduras to investigate the value of D.D.T. and Gammexane for the treatment of logs to prevent this type of infestation. This work has recently been extended to include tests with the water-dispersible Gammexane dust P. 520

Examination has been made of consignments of hardwoods reaching the Laboratory for routine tests, and records kept of defects caused by insects, starch content and susceptibility to infestation by powder-post beetles. Several enquirers have sought advice upon methods of preventing infestation by insects in various native timbers to be used for building in the ground-nut areas of East Africa, and known to be susceptible to attack.

Collections have been made of insects responsible for pinhole borer damage to tropical hardwoods and the species have been identified by the Commonwealth Institute of Entomology.

ENTOMOLOGICAL INSPECTIONS

Among the thirty-four inspections carried out was the annual inspection of the result of treatment of the infestation by death-watch beetle on H.M.S. Victory. Other places of interest visited were Christchurch Priory and the historic Maison Dieu House at Dover. An inspection of municipal housing estates severely infested by the common furniture beetle showed conditions typical of the damage caused by this insect in many parts of the country.

F. Y. HENDERSON,
Director

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Aylesbury, Bucks.

[1] FISHER, R. C., and HARRIS, E. C. A note on the Status of the House Longhorn Beetle, *Hylotrupes bajulus*, L., in Great Britain. (Submitted for publication in the *Proc. 8th Internat. Congr. Ent.* Stockholm, 1948.)

APPENDIX I

STAFF AT THE FOREST PRODUCTS RESEARCH LABORATORY
31*st December*, 1948

Director of Forest Products Research: F. Y. Henderson, D.Sc., D.I.C.

ADMINISTRATION

Assistant Director: S. T. C. Stillwell, O.B.E., B.Sc.
Senior Principal Scientific Officers: J. Bryan, M.Eng., A.M.Inst.C.E.; K. St.G. Cartwright, M.A., D.I.C., F.L.S.
Higher Executive Officer: L. Forbes.
Executive Officer: Miss D. Lacey.

SECTION OF WOOD STRUCTURE

Principal Scientific Officers: B. J. Rendle, B.Sc., A.R.C.S. (Officer in Charge); E. W. J. Phillips, B.Sc., Ph.D., A.R.C.S.
Scientific Officer: J. D. Brazier, B.Sc.
Experimental Officer: G. L. Franklin.
Assistant Experimental Officer: Miss L. F. P. Wood, B.Sc.

SECTION OF PHYSICS

Principal Scientific Officer: W. W. Barkas, D.Sc. (Officer in Charge).
Senior Scientific Officer: R. F. S. Hearmon, A.Inst.P.
Experimental Officer: J. McC. Paton.
Assistant Experimental Officer: J. N. Burcham.

SECTION OF SEASONING

Principal Scientific Officer: W. C. Stevens, M.A., A.M.I.Mech. E. (Officer in Charge).
Senior Experimental Officers: D. D. Johnston; R. E. Hodge, A.I.Mech.E.
Experimental Officers: A. R. Dean; G. H. Pratt; N. Turner.
Assistant Experimental Officers: Miss E. L. Bearn; B. R. Young.

SECTION OF TIMBER MECHANICS

Principal Scientific Officer: J. Latham, B.Sc. (Officer in Charge).
Senior Experimental Officer: A. J. Foord.
Assistant Experimental Officers: G. R. Brock; W. T. Currey; W. J. Garland; J. G. Sunley, B.Sc.

SECTION OF WOOD PRESERVATION

Principal Scientific Officer: N. A. Richardson, B.Sc., A.R.I.C. (Officer in Charge).
Senior Experimental Officer: D. N. Smith.
Experimental Officer: L. W. Redding.
Assistant Experimental Officers: Miss E. Lee; D. F. Purslow.
Temporary Assistant Experimental Officer: T. R. Suckling.

SECTION OF CHEMISTRY

Principal Scientific Officer: W. G. Campbell, B.Sc., M.S., A.R.I.C. (Officer in Charge).
Senior Scientific Officer: R. H. Farmer, B.A., B.Sc., D.Sc.Tech., F.R.I.C.
Experimental Officer: D. F. Packman.
Temporary Assistant Experimental Officer: Mrs. N. Bevan.

SECTION OF MYCOLOGY

Senior Principal Scientific Officer: K. St.G. Cartwright, M.A., D.I.C., F.L.S. (Officer in Charge).
Principal Scientific Officer: W. P. K. Findlay, D.Sc., A.R.C.S., D.I.C., A.I.C.T.A.
Scientific Officer: J. G. Savory, B.Sc.
Experimental Officer: E. C. Badcock.

SECTION OF ENTOMOLOGY

Principal Scientific Officer: R. C. Fisher, B.Sc., Ph.D. (Officer in Charge).
Senior Scientific Officer: J. D. Bletchly, B.A., B.Sc.
Experimental Officer: E. C. Harris
Temporary Assistant Experimental Officer: Miss N. E. Kent, B.Sc.

SECTION OF WOODWORKING

Principal Scientific Officers: P. Harris, B.Sc., A.M.I.Mech.E. (Officer in Charge); F. H. Armstrong, M.Sc., A.M.I.Mech.E.
Experimental Officer: H. J. Endersby.

SECTION OF EXTERNAL RELATIONS

Principal Scientific Officers: H. A. Cox, M.A., Dip.For., Dip.Tim.Tech. (special duty); C. W. Scott, O.B.E., D.F.C., B.Sc., Dip.For. (Officer in Charge).
Temporary Assistant Experimental Officer: Miss M. E. Smart, B.Sc.

SECTION OF COMPOSITE WOOD

Principal Scientific Officer: R. A. G. Knight, B.Sc. (Eng.), M.I.Mech.E. (Officer in Charge).
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Scientific Officer: J. F. S. Carruthers, B.Sc.
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APPENDIX II

List of Publications Issued During 1948

A. Stationery Office Publications

Solid and Laminated Wood Bending. By W. C. Stevens, M.A., A.M.I.Mech.E., and N. Turner.
Bulletin No. 21: Flooring Hardwoods, their Wear and Anatomical Structure. By F. H. Armstrong, M.Sc., A.M.I.Mech.E.
Special Report No. 7: The Elasticity of Wood and Plywood. By R. F. S. Hearmon.

(*For prices see page iii of cover*)

B. Other Publications

Leaflets*:
No. 42. Kiln-drying Schedules.
No. 43. D.D.T. Spray Treatment for Prevention of *Lyctus* Attack.

Papers Published in the Scientific and Technical Press:

Barkas, W. W. Hysteresis in the Swelling of Gels. *Nature*, 1948, **162**, 32.
Campbell, W. G. Modern Trends in the Chemical Utilization of Wood. *J. Oxford Univ. For. Soc.*, 1948, 3rd Series, No. **3**, 9–12.
Campbell, W. G., Hirst, E. L., and Jones, J. K. N. The ε-galactan of Larch Wood (*Larix decidua*). *J. chem. Soc.*, **1948**, 744–777.
Carruthers, J. F. S. The Cracking of Decorative Veneer Laid on Plywood. *Wood*, 1948, **13**(12), 344-346.
Farmer, R. H., and Campbell, W. G. Production of a Metallurgical Coke from the Resin of Wallaba Wood (*Eperua* sp.). *J. Soc. chem. Ind., Lond.*, 1948, **67**, 233-234.
Fisher, R. C. D.D.T. and Control of *Lyctus* Powder-post Beetles. *Emp. For. Rev.*, 1948, **27**(2), 303-305.
Latham, J. Agricultural Buildings. Strength Tests on Roof Truss and Purlins. *Wood*, 1948, **13**(7), 201-203.
Stevens, W. C. The Bending of Wood, *For. Abs.*, 1948, **9**(3), 265-271.
The Seasoning of Timber for High Class Joinery in Public Buildings. *Timb. News*, 1948, **56**(2113), 413, 416.
Forest Products Research Laboratory. A review of Recent Research Work. *Timb. Plywood* (Annual Number, **1947-1948**), 1948, 116, 118, 120.

* Obtainable gratis from the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.

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